2013

NONRESIDENTIAL ALTERNATIVE CALCULATION METHOD

REFERENCE MANUAL

FOR THE 2013 BUILDING ENERGY EFFICIENCY STANDARDS

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CALIFORNIA ENERGY COMMISSION
Edmund G. Brown Jr., Governor

Acknowledgments

The Building Energy Efficiency Standards (Standards) were first adopted and put into effect in 1978 and have been updated periodically in the intervening years. The Standards are a unique California asset and have benefitted from the conscientious involvement and enduring commitment to the public good of many persons and organizations along the way. The 2013 Standards development and adoption process continued that long-standing practice of maintaining the Standards with technical rigor, challenging but achievable design and construction practices, public engagement and full consideration of the views of stakeholders.

The 2013 Standards revision and the supporting documents were conceptualized, evaluated and justified through the excellent work of Energy Commission staff and consultants working under contract to the Energy Commission, Pacific Gas and Electric Company, Southern California Edison Company, San Diego Gas and Electric Company, and Southern California Gas Company. At the Energy Commission, Maziar Shirakh, P.E.; and Martha Brook, P.E. served as the project managers and senior engineers. Bill Pennington, Deputy Division Chief of the Efficiency and Renewable Energy Division, provided overall guidance to the staff and consultants. Eurlyne Geiszler served as the Office Manager for the High Performance Buildings Office. Pippin Brehler and Kristen Driskell provided legal counsel to the staff. This document was created with the technical assistance from Martha Brook, PE; Sabaratnam Thamilseran, PE, David Ware; Nelson Pena; Rob Hudler; and Owen Howlett. Other key technical staff contributors included, Gary Flamm; Patrick Saxton, P.E.; Jeff Miller, P.E.; Payam Bozorgchami, P.E.; Tav Commins; and Mark Alatorre. Additional staff input and assistance came from Ron Yasny; the Energy Hotline staff; and the Energy Commission's Web Team. Critical support for the staff in conceptualizing, evaluating, and reviewing this document came from Architectural Energy Corporation, L'Monte Information Services, Gard Analytics, National Renewable Energy Laboratory, Hitchcock consulting, 360 Analytics, Wrightsoft Corporation, Taylor Engineering, McHugh Energy, Gabel Associates, Energy Solutions, E3, PECI, and the Heschong Mahone Group.

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The Energy Commission dedicates the adoption of the 2013 Building Energy Efficiency Standards to ***Valerie T. Hall****, (November 28, 1952 - December 21, 2010), Deputy Director of the Efficiency and Renewable Energy Division for her more than 32 years of dedication to excellence in the development and implementation of energy efficiency programs in California with the most aggressive energy efficient building standards in the country and for being a model for others to follow.*

ABSTRACT

The 2013 Building Energy Efficiency Standards for Nonresidential Buildings allow compliance by either a prescriptive or performance method. Performance compliance uses computer modeling software to trade off efficiency measures. Computer performance compliance is typically the most popular compliance method because of the flexibility it provides in the building design.

Energy compliance software must be certified by the Energy Commission, following rules established for the modeling software. This document establishes the rules for the process of creating a building model, describing how the proposed design (energy use) is defined, how the standard design (energy budget) is established, and ending with what is reported on the Performance Compliance Certificate (PRF-1). This Nonresidential Alternative Calculation Method (ACM) Reference Manual explains how the proposed and standard designs are determined. This document also establishes the procedure for performance calculation, necessary rule sets, reference method for testing Compliance Software accuracy and the minimum reporting requirements.

The 2013 Compliance Software is the simulation and compliance rule implementation software specified by the Energy Commission. The Compliance Manager, called California Building Energy Code Compliance (CBECC), models all features that affect the energy performance of the building. This document establishes the process of creating a building model. Each section describes how a given component, such as a wall or fenestration is modeled for the proposed design, standard design, and ends with what is reported on the Performance Compliance Certificate (PRF-1) for verification by the building enforcement agency.

Keywords: ACM, Alternative Calculation Method, Building Energy Efficiency Standards, California Energy Commission, California Building Energy Code Compliance, CBECC, Performance Compliance Certificate (PRF-1), compliance manager, compliance software, computer compliance, energy budget, Time Dependent Valuation (TDV), energy standards, energy use, prescriptive compliance, performance compliance, design, proposed design, standard design

2013 Title 24
Nonresidential ACM Reference Manual

Revision December 2015

This version of the Nonresidential ACM Reference Manual incorporates supported requirements for new construction, additions and alterations, partial compliance, and contains requirements for programs that use only two-dimensional (2D) geometry as a “Simplified Method” for expressing building geometry in the simulation model. The requirements in this ACM Reference Manual version are consistent with the implementation in the latest CBECC-Com software release. Adjustments to unmet load hour handling are made to this version to accommodate users adjusting to the new future, and may be changed in a future compliance software and ACM release.

Change Log:

Version	Date	Change	Section(s)	Details
ERRATA	3/20/15	General Lighting Power	5.4.4	Clarified rule for existing, altered – software doesn’t account for individual luminaires
ERRATA	3/20/15	Zone Exhaust, Outdoor Air	5.6.5.3, 5.6.5.4	Updates for exhaust and ventilation settings for covered processes
ERRATA 4.5	3/1/2015	Adjusted Unmet Load Hour Rules	2.4	Excess UMLH now generate warning; requirements relaxed for specific zones, such as corridors and bathrooms)
ERRATA 4.5	3/5/2015	Water Heating Standard Design sizing	5.9.1.2	If proposed design capacity does not meet prescribed hot water loads, allow proposed sizing and size baseline based on 60% heat input capacity and 40% storage
ERRATA 4.5	3/4/2015	Fenestration Type	5.5.7	Change standard fenestration type to match proposed design fenestration type

ERRATA 4.4	1/30/2015	Fan Power Part Load Curve	5.7.3.2 (Table 30)	Revise prescribed fan power part-load performance curve for multi-zone VAV systems with static pressure reset
ERRATA 4.4	1/30/2015	Modified baseline SAT to be 60F for interior zones of multi-zone systems only	5.7.2.3	Previous rule set baseline SAT for 60F for interior zones of all systems
ERRATA 4.3	9/3/2014	Adjusted baseline number of cooling stages for PVAV systems	5.7.5.2	Standard Design is “2” for both single zone VAV and PVAV baseline systems
ERRATA 4.3	8/21/2014	Clarified Proposed Design Input for Return/Relief Fan Design Capacity	5.7.3.3	Value is “As Designed”
ERRATA	8/12/2014	Clarified “Gross Total Cooling Capacity” at rated conditions, which is not a user input.	5.7.5.1	Value is calculated by definition of AHRI fan power and by user entry of net cooling capacity
ERRATA 4.2	7/25/2014	Clarified exhaust air flow sizing, especially for covered processes; minor updates to covered process summary definitions	5.7	See sections for detail; for covered processes, based supply air flow sizing on exhaust air flow where appropriate
ERRATA version 4.1	5/21/2014	Added additions and alterations test case summary to chapter 3	3	
ERRATA version 4.0	4/30/2014	Minor updates to Reference Method tests to incorporate 2D geometry test cases for this feature	3	See sections 3.4 and 3.5
ERRATA version 4.0	4/30/2014	Added Simplified Geometry description for tools that do not support 3D geometry	5.5.11	See section for description
ERRATA Version 4.0	4/10/2014	Added Clarification of Rules for Additions, Alterations and Partial Compliance Scenarios	5	Added rules consistent with Standards requirements for A&A and partial compliance; clarified extent of model required for additions and alterations

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1. Overview

1.1 Purpose

This document is the California Nonresidential ACM Reference Manual. It explains the requirements for approval of nonresidential compliance and Compliance Software in California. Approved software is used for two purposes: to demonstrate minimum compliance with the California energy efficiency standards and to achieve beyond-code energy performance needed to qualify for Reach standards. The procedures and processes described in this manual are designed to provide consistency and accuracy while preserving the integrity of the process of Compliance and Reach. This manual addresses software for nonresidential buildings, hotels & motels, and high-rise residential buildings as outlined in Title 24, Part 6, Subchapter 5, §140.1. A separate ACM Reference Manual applies to low-rise residential buildings. The approval process for nonresidential software programs is specified in Title 24, Part 1, §10-101 through §10-110 of the California Code of Regulations.

1.2 Modeling Assumptions

When calculating annual energy use, it is necessary to make assumptions about how the proposed building is operated. Operating assumptions include thermostat settings, number of occupants, receptacle loads, process loads, hot water loads as well as schedules of operation for HVAC systems, lighting systems and other systems. Sometimes these data are known with some certainty and other times (for instance for speculative buildings), it is necessary to make estimates. These inputs are prescribed (they are fixed for both the proposed design and for the baseline building and can’t be changed. Some of these inputs are prescribed (they are fixed for both the proposed design and for the baseline building and can’t be changed), while others are defaults for California Compliance and for California Reach.

1.3 Scope

This manual is intended to be used for software programs seeking certification as Title 24 compliance software for nonresidential buildings.

The long-term goal of this manual is to define modeling rules and procedures for all common design features that are incorporated in commercial buildings. The authors recognize, however, that this goal cannot be fully achieved due to limitations in the development energy simulation algorithms, and due to the natural lag time between the introduction of an advanced energy efficiency measure or device and the development of algorithms to simulate its performance.

Since the ACM Reference Manual can be modified during a code cycle without a formal rulemaking, updates can be made to improve the accuracy and usability of compliance software.

1.4 Organization

This document is organized in five chapters and several appendices, as described below:

Chapter	**Description**
1. Overview	The purpose, organization, content, and intent of the manual (this chapter).
2. General Modeling Procedures	An overview of the modeling process, outlining the modeling rules and assumptions that are implemented in the same way for both the standard design and the proposed design, and procedures for determining system types and equipment sizes.
3. Software Requirements	Requirements for the simulation engines and software shells that are used to make calculations, and special reporting requirements for non-standard building features.
4. Content and Format of Standard Reports	The content and organization of the standard reports that need to be produced by qualifying software.
5. Building Descriptors Reference	The acceptable range of inputs for the proposed design and a specification for the standard design.

In addition, a number of appendices are provided that contain reference material that support definition of the proposed design and standard design. The numbering for these appendices generally aligns with the section numbers in the main manual that reference the appendices.

1.5 Reference Method

The reference procedures and method described in this manual establish the basis of comparison for all software. The approval process ensures that a minimum level of energy efficiency is achieved regardless of the software used. This is accomplished by;

- specifying a series of Reference Method comparison tests that candidate software must pass,
- specifying input which may be varied in the compliance process for credit and input that is fixed or restricted,
- defining standard report output requirements,
- software vendor-certification to the requirements in this manual.

The Nonresidential ACM Reference Manual is an approved document, separate from the formally adopted ACM regulations. This gives the Commission the flexibility to incorporate new modeling procedures or features, or fix errata, within the code cycle. The document is said to be in continuous maintenance. Software may be certified with the capability of modeling specific building systems or features.

The Commission's purpose in approving additional capabilities is to accommodate new technologies which have only begun to penetrate the market and new modeling algorithms. Newly added capabilities which evaluate measures already in relatively common use shall have their standard design for the measure based on the common construction practice (or the typical base situation) for that measure since common practice is the inherent basis of the standards for all measures not explicitly regulated. For example, the Commission has no interest in an optional capability that evaluates the energy impacts of dirt on windows unless a new technology produces substantial changes in this aspect of a building relative to buildings without this technology. The burden of proof that an additional capability should be approved lies with the applicant.

Companion documents which are helpful to prepare software for certification include the latest editions of the following Commission publications:

- Energy Efficiency Standards
- Appliance Efficiency Regulations
- Nonresidential Compliance Manual
- Nonresidential ACM Approval Manual
- Reference Nonresidential Appendices
- Reference Joint Appendices

In this manual the term "Standards" means the Building Energy Efficiency Standards, Title 24, Part 6 of the California Code of Regulations. The term "compliance" means that a building design in an application for a building permit complies with the "Standards" and meets the requirements described for building designs therein.

There are a few special terms that are used in this Manual. The Commission approves software for use in demonstrating compliance. Commission approval means that the Commission accepts the applicant's certification that software meets the requirements of this Manual. The proponent of candidate software is referred to as a vendor. The vendor shall follow the procedure described in this document to publicly certify to the Commission that the software meets the criteria in this document for:

- Accuracy and reliability when compared to the Reference Method; and
- Suitability in terms of the accurate calculation of the correct energy budget, the generation of output for transmission to standardized forms, and the documentation on how the program demonstrates compliance.

In addition to explicit technical criteria, Commission approval will also depend upon the Commission's evaluation of:

- Enforceability in terms of reasonably simple, reliable, and rapid methods of verifying compliance and application of energy efficiency features modeled by the software and the inputs used to characterize those features by the software users.
- Dependability of the installation and energy savings of features modeled by the software. The Commission will evaluate the probability of the measure actually being installed and remaining functional. The Commission shall also determine that the energy impacts of the features that the software is capable of modeling will be reasonably accurately reflected in real building applications of those features. In particular, it is important that the software does not encourage the replacement of actual energy savings with theoretical energy savings due to tradeoffs allowed by the software.

For the vendor, the process of receiving approval of software includes preparing an application, working with the Commission staff to answer questions from either Commission staff or the public, and providing any necessary additional information regarding the application. The application includes the four basic elements outlined below. The Commission staff evaluates the software based on the completeness of the application and its overall responsiveness to staff and public comment.

The four basic requirements for approval include:

1. Required capabilities:

   Software shall have all the required input capabilities explained in Chapter 2.

   Software shall meet software requirements and documentation requirements for applicable features supported by the software, as described in Chapter 3.

2. Accuracy of simulation:

   The software shall demonstrate acceptable levels of accuracy by performing and passing the required certification tests discussed in Appendix 3B.

   The software vendor conducts the specified certification tests in Appendix 3B, evaluates the results and certifies in writing that the software passes the tests. The Commission will perform spot checks and may require additional tests to verify that the proposed software is appropriate for compliance purposes.

   When energy analysis techniques are compared, two potential sources of discrepancies are the differences in user interpretation when entering the building specifications, and the differences in the software's algorithms (mathematical models) for estimating energy use. The approval tests minimize differences in interpretation by providing explicit detailed descriptions of the test buildings that must be analyzed. For differences in the software's algorithms, the Commission allows algorithms that yield equivalent results.

3. User's Manual:

   The vendor shall include a User's Manual and/or help system that provides appropriate guidance for specifying inputs and running a simulation for compliance.

4. Program support:

   The vendor shall provide ongoing user and enforcement agency support as described in the Nonresidential ACM Approval Manual.

The Commission may hold one or more workshops with public review and vendor participation to allow for public review of the vendor's application. Such workshops may identify problems or discrepancies that may necessitate revisions to the application.

Commission approval of software programs is intended to provide flexibility in complying with the Standards. However, in achieving this flexibility, the software shall not degrade the standards or evade the intent of the Standards to achieve a particular level of energy efficiency. The vendor has the burden of proof to demonstrate the accuracy and reliability of the software relative to the reference method and to demonstrate the conformance of the software to the requirements of this manual.

1.6 Compliance

1.6.1 Type of Project Submittal

Software shall require the user to identify the type of project; either Compliance or Reach. The software shall require the user to choose one of the following options:

- New Building or Addition Alone. Software may do this by treating an addition alone as a new building, but an addition modeled in this way shall be reported on all output forms as an Addition (modeled alone).
- Alteration of Existing Building.
- Alteration of Existing Building plus Addition.

1.6.2 Scope of Compliance Calculations

For each building or separately permitted space, software shall also require the user to identify the scope of the compliance submittal from the following list:

- Envelope only
- Envelope and Lighting
- Envelope and Partial Lighting
- Envelope and Mechanical
- Mechanical only
- Mechanical and Lighting
- Mechanical and Partial Lighting
- Envelope, Lighting and Mechanical (newly constructed building)

Each of these situations requires specific assumptions, input procedures and reporting requirements. Modeling assumptions are documented in Chapter 5. Reporting requirements are documented in Chapter 4. Software shall only produce compliance reports specific to the scope of the submittal determined for the run. For example, an Envelope Only scope run will produce a PRF-01 form with only information relevant to the Envelope.

Lighting compliance for a partial compliance scenario may be for the entire building, or may be specified for only portions of the building. When the building applies for partial lighting compliance, the space(s) where lighting for the space is unknown or undefined shall be marked as “Not Applicable”, and the compliance software shall use the Standard Design lighting power for the user-defined space type for both the Proposed Design and Standard Design. Under this compliance scope, the entire building shall be modeled, and the compliance forms shall indicate the spaces for which lighting compliance is not performed.

The following modeling rules apply for when the scope of the compliance calculations do not include one of the following: the building envelope, the lighting system or the mechanical system.

Table 1: Compliance Options

Cases	Modeling Rules for Proposed Design	Modeling Rules for Standard Design (All):
No Envelope Compliance Mechanical Only Mechanical and Lighting	The envelope shall be modeled according to the as-built drawings and specifications of the building or as it occurs in the previously-approved compliance documentation of the building. All envelope features and inputs required for software by this manual shall be entered. Note: A partial permit application involving no envelope compliance creates an exceptional condition. This requires either a copy of the previous envelope compliance approval or an equivalent demonstration by the applicant (to the satisfaction of the local enforcement agency) that the building is conditioned and an occupancy permit has previously been issued by the local enforcement agency.	The envelope shall be identical to the proposed design.

No Mechanical Compliance Envelope Only Envelope and Lighting	Software shall model the proposed design HVAC system according to the standard design rules in Chapter 5, using the standard design system map for determining HVAC system type.	The mechanical systems shall be identical to the proposed design.
No Lighting Compliance Envelope Only Mechanical Only Envelope and Mechanical	Previously-approved lighting plans with approved lighting compliance forms may be entered. The exceptional conditions list on the PRF-1 form shall indicate that previously-approved lighting plans and compliance forms shall be resubmitted with the application.	The baseline building lighting system shall be identical to the proposed design.
	In the absence of approved lighting plans and lighting compliance forms, the software shall model the standard design lighting system corresponding to the user-defined space types.	The baseline building lighting system shall be identical to the proposed design.

1.6.3 Climate Zones

The program shall account for variations in energy use due to the effects of the California climate zones and local weather data. Climate information for compliance simulations shall use the applicable data set in Reference Appendix JA2.

1.6.4 Time Dependent Valuation

The candidate software shall calculate the hourly energy use for both the standard design and the proposed design by applying a TDV factor for each hour of the reference year. TDV factors have been established by the CEC for residential and nonresidential occupancies, for each of the climate zones, and for each fuel (electricity, natural gas, and propane). The procedures for Time Dependent Valuation of energy are documented in Reference Appendix JA3.

1.6.5 Reporting Requirements for Unsupported Features

The compliance software shall meet required capabilities and pass applicable certification tests as defined in Appendix 3A, Appendix 3B and Appendix 3C. While the vendor’s software does not need to implement every modeling rule in the ACM reference manual, all software features, systems, components and controls that are modeled must follow the modeling guidelines in the ACM Reference Manual. Vendors seeking certification for software programs to be used for Title 24 compliance should clearly state the extent of the capabilities of their software with respect to compliance. Support of a modeling feature includes correctly processing user input, specifying the standard design correctly, applying that information to simulation models, and processing the results.

Any building features or systems that cannot be modeled in a compliance software program shall show compliance using prescriptive forms.

1.7 Approval Process

1.7.1 Application Checklist

The following items shall be included in an application package submitted to the Commission for software approval:

- Compliance Software Vendor Certification Statement. A copy of the statement contained in Appendix A, signed by the software vendor, certifying that the software meets all Commission requirements, including accuracy and reliability when used to demonstrate compliance with the energy standards.
- Computer Runs. Copies of the computer runs specified in Chapter 3 of this manual on machine readable form as specified in Chapter 3 to enable verification of the runs.
- Help System and/or User's Manual. The vendor shall submit a complete copy of the help system and/or software user's manual, including material on the use of the software for compliance purposes.
- Copy of the Compliance Software and Weather Data. A machine readable copy of the software for random verification of compliance analyses. The vendor shall provide weather data for all 16 climate zones.
- TDV Factor Documentation. The software shall be able to apply the TDV multipliers described in Reference Appendix JA3.
- Application Fee. The vendor shall provide an application fee of $2,000.00 (two thousand dollars) as authorized by §25402.1(b) of the Public Resources Code, made out to the "State of California" to cover costs of evaluating the application and to defray reproduction costs.

A cover letter acknowledging the shipment of the completed application package should be sent to:

Executive Director
California Energy Commission
1516 Ninth Street, MS-39
Sacramento, CA 95814-5512

Two copies of the full application package should be sent to:

Compliance Software Nonresidential Certification
California Energy Commission
1516 Ninth Street, MS-37
Sacramento, CA 95814-5512

Following submittal of the application package, the Commission may request additional information pursuant to Title 24, Part 1, §10-110. This additional information is often necessary due to complexity of software. Failure to provide such information in a timely manner may be considered cause for rejection or disapproval of the application. A resubmittal of a rejected or disapproved application will be considered a new application, including a new application fee.

1.7.2 Types of Approval

This Manual addresses two types of software approval: full program approval (including amendments to programs that require approval), and approval of new program features and updates.

If software vendors make a change to their programs as described below, the Commission shall again approve the program. Additionally, any software change that affects the energy use calculations for compliance, the modeling capabilities for compliance, the format and/or content of compliance forms, or any other change which would affect Compliance or Reach requires another approval.

Changes that do not affect Compliance or Reach, such as changes to the user interface, may follow a simplified or streamlined procedure for approval. To comply with this simpler process, the software vendor shall certify to the Commission that the new program features do not affect the results of any calculations performed by the program, shall notify the Commission of all changes and shall provide the Commission with one updated copy of the program and Help System/User's Manual. Examples of such changes include fixing logical errors in computer program code that do not affect the numerical results (bug fixes) and new interfaces.

1.7.2.1 Full Approval & Re-Approval of Compliance Software

The Commission requires program approval when candidate software has never been previously approved by the Commission, when the software vendor makes changes to the program algorithms, or when any other change occurs that in any way affects the compliance results. The Commission may also require that all currently approved software be approved again whenever substantial revisions are made to the Standards or to the Commission's approval process.

The Commission may change the approval process and require that all software be approved again for several reasons including:

- If the standards undergo a major revision that alters the basic compliance process, then software would have to be updated and re-approved for the new process.
- If new analytic capabilities come into widespread use, then the Commission may declare them to be required software capabilities, and may require all software vendors to update their programs and submit them for re-approval.

When re-approval is necessary, the Commission will notify all software vendors of the timetable for renewal. A new version of this manual will be published and the Commission will provide instructions for re-approval.

Re-approval shall be accompanied by a cover letter explaining the type of amendment(s) requested and copies of other documents as necessary. The timetable for re-approval of amendments is the same as for full program approval.

1.7.2.2 Approval of New Features & Updates

Certain types of changes may be made to previously approved nonresidential software through a streamlined procedure, including implementing a computer program on a new machine and changing executable program code that does not affect the results.

Modifications to previously approved software including new features and program updates are subject to the following procedure:

- The software vendor shall prepare an addendum to the Compliance Supplement or software user's manual, when new features or updates affect the outcome or energy efficiency measure choices, describing the change to the software. If the change is a new modeling capability, the addendum shall include instructions for using the new modeling capability for compliance.
- The software vendor shall notify the Commission by letter of the change that has been made to the software. The letter shall describe in detail the nature of the change and why it is being made. The notification letter shall be included in the revised Compliance Supplement or software user's manual.
- The software vendor shall provide the Commission with an updated copy of the software and include any new forms created by the software (or modifications in the standard reports).

The Commission will respond within 45 days. The Commission may approve the change, request additional information, refuse to approve the change, or require that the software vendor make specific changes to either the Compliance Supplement addendum or the software program itself.

With Commission approval, the vendor may issue new copies of the software with the Compliance Supplement addendum and notify software users and building officials.

1.7.3 Challenges

Building officials, program users, program vendors, Commission staff or other interested parties may challenge any nonresidential software approval. If any interested party believes that a compliance program, an algorithm or method of calculation used in a compliance program, a particular capability or other aspect of a program provides inaccurate results or results which do not conform to the criteria described in his manual, the party may initiate the challenge of the program.

1.7.4 Decertification of Compliance Software Programs

The Commission may decertify (rescind approval of) an alternative calculation method through the following means:

- All software programs are decertified when the Standards undergo substantial changes which occur about every three years.
- Any software can be decertified by a letter from the software vendor requesting that a particular version (or versions) of the software be decertified. The decertification request shall briefly describe the nature of the program errors or "bugs" which justify the need for decertification.
- Any "initiating party" may commence a procedure to decertify an software according to the steps outlined below. The intent is to include a means whereby unfavorable software tests, serious program errors, flawed numeric results, improper forms and/or incorrect program documentation not discovered in the certification process can be verified, and use of the particular software version discontinued. In this process, there is ample opportunity for the Commission, the software vendor and all interested parties to evaluate any alleged problems with the software program.

NOTE 1: The primary rationale for a challenge is unfavorable software tests, which means that for some particular building design with its set of energy efficiency measures, the software fails to meet the criteria used for testing software programs described in Chapter 3.

NOTE 2: Flawed numeric results where the software meets the test criteria in Chapter 3, in particular when software fails to properly create the baseline building.

Following is a description of the process for challenging software or initiating a decertification procedure:

1. Any party may initiate a review of software's approval by sending a written communication to the Commission's Executive Director. (The Commission may be the initiating party for this type of review by noticing the availability of the same information listed here.)

   The initiating party shall:

   - State the name of the software and the program version number(s) which contain the alleged errors;
   - Identify concisely the nature of the alleged errors in the software which require review;
   - Explain why the alleged errors are serious enough in their effect on analyzing buildings for compliance to justify a decertification procedure; and,
   - Include appropriate data on any media compatible with Windows XP or above and/or information sufficient to evaluate the alleged errors.
2. The Executive Director shall make a copy or copies of the initial written communication available to the software vendor and interested parties within 30 days.

3. Within 75 days of receipt of the written communication, the Executive Director may request any additional information needed to evaluate the alleged software errors from the party who initiated the decertification review process. If the additional information is incomplete, this procedure will be delayed until the initiating party submits complete information.
4. Within 75 days of receipt of the initial written communication, the Executive Director may convene a workshop to gather additional information from the initiating party, the software vendor and interested parties. All parties will have 15 days after the workshop to submit additional information regarding the alleged program errors.
5. Within 90 days after the Executive Director receives the application or within 30 days after receipt of complete additional information requested of the initiating party, whichever is later, the Executive Director shall either:
   - Determine that the software need not be decertified; or,
   - Submit to the Commission a written recommendation that the software be decertified.
6. The initial written communication, all other relevant written materials, and the Executive Director's recommendation shall be placed on the calendar and considered at the next business meeting after submission of the recommendation. The matter may be removed from the consent calendar at the request of one of the Commissioners.
7. If the Commission approves the software decertification, it shall take effect 60 days later. During the first 30 days of the 60-day period, the Executive Director shall send out a Notice to Building Officials and Interested Parties announcing the decertification.

All initiating parties have the burden of proof to establish that the review of alleged software errors should be granted. The decertification process may be terminated at any time by mutual written consent of the initiating party and the Executive Director.

As a practical matter, the software vendor may use the 180- to 210-day period outlined here to update the software program, get it re-approved by the Commission, and release a revised version that does not have the problems initially brought to the attention of the Commission. Sometimes the software vendor may wish to be the initiating party to ensure that a faulty program version is taken off the market

1.8 Vendor Requirements

Each vendor shall meet all of the following requirements as part of the software approval process and as part of an ongoing commitment to users of their particular program.

1.8.1 Availability to Commission

All software vendors are required to submit at least one fully working program version of the software to the California Energy Commission. An updated copy or access to the approved version of the software shall be kept by the Commission to maintain approval for compliance use of the software.

The Commission agrees not to duplicate the software except for the purpose of analyzing it, for verifying building compliance with the compliance software, or to verify that only approved versions of the software are used for compliance.

1.8.2 Enforcement Agency Support

Software vendors shall provide a copy of the software User’s Manual / Help System to all enforcement agencies who request one in writing.

1.8.3 User Support

Software vendors shall offer support to their users with regard to the use of the software for Compliance or Reach purposes. Vendors may charge a fee for user support.

1.8.4 Compliance Software Vendor Demonstration

The Commission may request software vendors to offer a live demonstration of their software's capabilities. One or more demonstration may be requested before approval is granted.

2. General Modeling Procedures

2.1 General Requirements for Data from the User

2.1.1 General

This document lists the building descriptors that are used in the compliance simulation. Users must provide valid data for all descriptors that do not have defaults specified and that apply to parts of the building that must be modeled.

2.1.2 Building Envelope Descriptions

The user shall provide accurate descriptions for all building envelope assemblies including exterior walls, windows, doors, roofs, exterior floors, slab-on-grade floors, below grade walls and below grade floors. The user shall provide data for all of the required descriptors listed in section 5.5 that correspond with these assemblies. However, the following exceptions apply:

- Exterior surfaces whose azimuth orientation and tilt differ by no more than 45° and are otherwise the same may be described as a single surface or described using multipliers. This specification would permit a circular form to be described as an octagon.

2.1.3 Space Use Classification

The user must designate space use classifications that best match the uses for which the building or individual spaces within the building are being designed. Space use classifications determine the default or prescribed occupant density, occupant activity level, receptacle power, service water heating, lighting load, area-based minimum outdoor ventilation air, daylighting setpoints, and operating schedules used in the analysis. Process loads and refrigeration loads are also provided for applicable space types.

The user must specify the space use classifications using either the complete *building* or *area category* methods but may not combine the two types of categories within a single analysis. The building area method assigns assumptions based on average values that occur within typical buildings of the designated type. The complete building method is recommended for use when detailed space planning information is unavailable. More than one building area category may be used in a building if it is a mixed-use facility.

The area category method uses the area category categories in the standard design, which were developed for lighting requirements. The area category method requires area category entry of floor area and space use designations. The area category method can be used whenever design information is available with the necessary detail.

The user may override the default assumptions for some building descriptors dependent on the space use classification with supporting documentation. Details are provided in section 5.4 of this manual.

2.1.4 Treatment of Descriptors Not Fully Addressed By This Document

The goal for this document is to provide input and rating rules covering a full range of energy-related features encountered in commercial buildings. However, this goal is unlikely to ever be achieved due to the large number of features that must be covered and the continuous evolution of building materials and technologies. For compliance and for Reach code, building features or systems not covered in this manual must apply for approval via the Exceptional Calculation method to the Commission. However, this manual may be amended with provisions to model additional features or HVAC systems during the code cycle. When this occurs, it is the responsibility of the software vendor to pass the necessary acceptance tests and apply for approval for the new building feature(s).

2.2 Thermal Zones, HVAC Zones and Space Functions

2.2.1 Definitions

A *thermal zone* is a space or collection of spaces within a building having sufficiently similar space conditioning requirements so that those conditions could be maintained with a single thermal controlling device. A thermal zone is a thermal and not a geometric concept: spaces need not be contiguous to be combined within a single thermal zone. However, daylighting requirements may prevent combining non-contiguous spaces into a single thermal zone.

An *HVAC zone* is a physical space within the building that has its own thermostat and zonal system for maintaining thermal comfort. HVAC zones are identified on the HVAC plans. HVAC zones should not be split between thermal zones, but a thermal zone may include more than one HVAC zone.

A *space function* is a sub-component of a thermal zone that has specific standard design lighting requirements and for which there are associated defaults for outside air ventilation, occupancy, receptacle loads, and hot water consumption. An *HVAC zone* may contain more than one *space function*. Appendix 5.4A has a list of the space functions that may be used with the software. Daylighted areas should generally be defined as separate space functions, even if they have the same classification from Appendix 5.4A, so that lighting reductions due to daylighting can be determined at the appropriate resolution.

Figure 1 shows the hierarchy of *space functions, HVAC zones* and *thermal zones*.

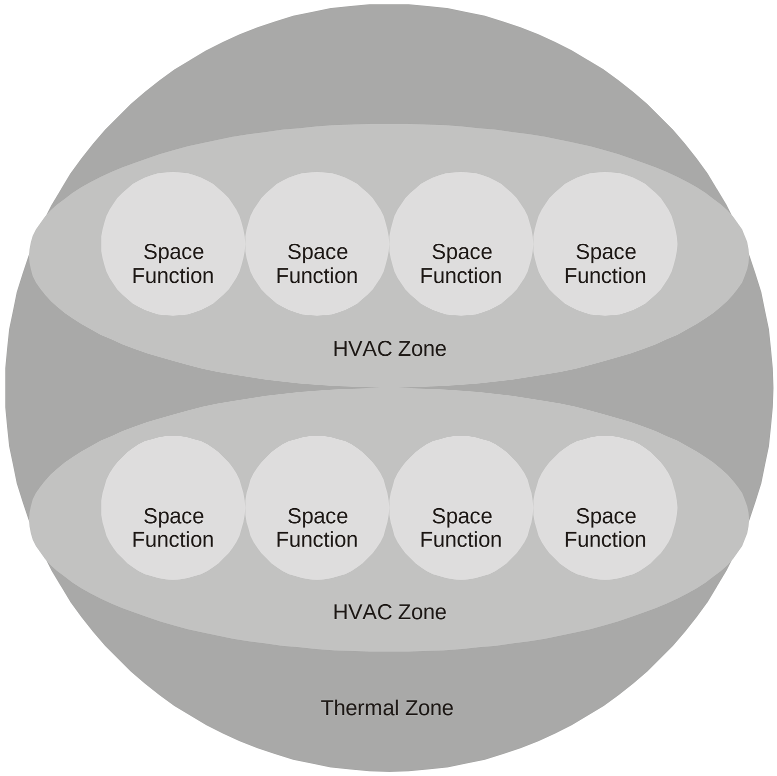


Figure 1 – Hierarchy of Space Functions, HVAC Zones and Thermal Zones

2.3 Software Modeling Requirements for Zones

2.3.1 Required Zone Modeling Capabilities

For California compliance, software shall accept input for and be capable of modeling a minimum of fifty (50) thermal zones, each with its own control. Software shall also be capable of reporting the number of control points at the building level. When the number of control points is not greater than twenty (20) the compliance software shall have one HVAC zone per control point. Compliance software may use zone multipliers for identical zones. When the number of zones exceeds twenty (20), then (and only then) thermal zones may be combined subject to a variety of rules and restrictions.

2.3.2 Modeling Requirements for Unconditioned Spaces

Unconditioned space is enclosed space that is neither directly nor indirectly conditioned. Examples include stairways, warehouses, unoccupied adjacent tenant spaces, attached sunspaces, attics and crawl spaces.

Unconditioned spaces shall be modeled if they are part of the permitted space. All applicable envelope information shall be specified in a similar manner to conditioned space.

If unconditioned space is not a part of the permitted space, the space may be either explicitly modeled or its impact on the permitted space may be approximated by modeling the space as outdoor space and turning off solar gains to the demising wall that separates the permitted space from the adjacent unconditioned space. For unconditioned spaces that are explicitly modeled, all internal gains and operational loads (occupants, water heating, receptacle, lighting and process loads) shall be modeled as specified in Appendix 5.4A.

Return air plenums are considered indirectly conditioned spaces and shall be modeled as part of the adjacent conditioned space with equipment, lighting and occupant loads at zero.

Indirectly conditioned spaces can either be occupied or unoccupied. For spaces that are unoccupied, such as plenums, attics or crawlspaces, lighting, receptacle and occupant loads shall be zero. For spaces that can be occupied, such as stairwells or storage rooms, modeling assumptions shall be taken from Appendix 5.4A.

Unconditioned spaces may not be located in the same zone as conditioned spaces. Conditioned spaces and indirectly conditioned spaces may be located in the same zone; when this occurs, the indirectly conditioned spaces will assume the space temperature schedule of the conditioned space.

2.3.3 Space Use Classification Considerations

Thermal zones shall contain no more than ten different space functions, which shall only be combined if the spaces have similar space conditioning requirements. If the complete building method is used, each thermal zone must be assigned to one and only one complete building type. For California compliance, space function inputs, as how they translate to thermal zone and HVAC system analysis assumptions are defined by the following rules:

<u>Schedule Group:</u> 13 different *schedule groups* are defined in Appendix 5.4B for California compliance. Each schedule group defines building specific hourly profiles for thermostat setpoints, HVAC system availability, occupancy, lighting, etc.

<u>Space Functions:</u> Each building space is assigned one *space function*. Design internal loads and other space function input assumptions, including the assigned schedule group described above, are defined in Appendix 5.4A. The schedule group and the schedule values for each space function are prescribed for compliance analysis, with the exception of the following space functions:

- Corridors, Restrooms, Stairs, and Support Areas
- Electrical, Mechanical, Telephone Rooms
- Laundry
- Lobby, Main Entry
- Locker/Dressing Room
- Waiting Area

These space functions are common to many different building types, and therefore, the user can assign any of the available schedule groups defined in Appendix 5.4B. This mitigates the issue of conflicting schedule profiles if these common functions are combined into a single thermal zone or served by the same HVAC system as surrounding zones. In the event the user does not assign a schedule group to these common space types, default assumptions are defined in the Appendix 5.4B.

Thermal Zones: Spaces can be combined into thermal zones. In this situation, peak internal loads and other design inputs for the thermal zone are determined by weight-averaging the space function design inputs by floor area. However, if the peak lighting, receptacle, and process load of the individual space functions differs by more than 2 Watts/ft^2 or a factor of 2, the space functions cannot be combined into a single thermal zone. If spaces combined into thermal zones meet these criteria, the thermal zone schedules are based on the schedule group of the predominant space function (by floor area) included in the thermal zone.

HVAC Systems: In many cases, more than one conditioned thermal zone is served by a single HVAC system, which is has scheduled availability (ON or OFF) to address the occupancy and internal load patterns of the thermal zones it serves. For systems that serve more than one thermal zone, the HVAC Schedule Group and availability schedule is determined by the most predominant schedule group (by floor area) represented in the thermal zones served.

If peak lighting, receptacle, or process loads of the individual thermal zones differs by more than 2 Watts/ft^2 or a factor of 2, the compliance software will identify this HVAC system and the range of peak thermal zone internal loads for the given system in the final compliance report; however, compliance analysis will still be performed.

The Schedule Group in the Standard Design is defined for each building story according to the predominant space function type and the Schedule Group assignment in Appendix 5.4A. Residential spaces and Covered Process spaces shall be served by dedicated systems, separate from nonresidential spaces.

In the rare case that the predominant schedule group for the thermal zones/HVAC system cannot be determined by floor area (i.e. two or more different schedule groups are represented by equal floor areas), the schedule group corresponding to the combined space functions or thermal zones with the highest combined peak lighting and receptacle load shall be used at each respective step described above.

2.4 Unmet Load Hours

This manual uses the term “Unmet Load Hours” (UMLH) as a criterion for sizing equipment, for qualifying natural ventilation systems, and for other purposes. The concept of unmet load hours applies to individual thermal zones but is summed for hours whenever any thermal zone in the building has unmet loads. For a thermal zone, it represents the number of hours during a year when the HVAC system serving the thermal zone is unable to maintain the set point temperatures for heating and/or cooling. During periods of unmet loads, the space temperature drifts above the cooling setpoint or below the heating setpoint. A thermal zone is considered to have an unmet load hour if the space is outside the throttling range for heating or cooling. The throttling range is defined in Chapter 5 as the space temperature difference between no cooling and full cooling or between no heating and full heating. It is assumed that the cooling and heating setpoints are “centered” on the throttling range, so that a cooling setpoint of 75°F results in an acceptable temperature band of 74°F to 76°F. The throttling range is fixed at 2°F for simulating both the standard design and proposed design.

An unmet load hour can occur only during periods when the HVAC system is scheduled to operate. Unmet load hours are accounted for in each zone of the building. No zone in the building should exceed the maximum allowed unmet load hours.

Unmet load hours can occur because fans, air flows, coils, furnaces, air conditioners or other equipment is undersized. Unmet load hours can also occur due to user errors including mismatches between the thermostat setpoint schedules and HVAC operating schedules or from other input errors, for instance, high internal gains or occupant loads. The term, as used in this manual, only addresses equipment that is undersized. It is the responsibility of the user to address other causes of unmet load hours in the proposed design.

Unmet load hours apply to thermal zones that contain any space type that is normally occupied. Thermal zones that only contain the space types listed below will not have unmet load hours applied to them:

- Commercial and Industrial Storage Areas
- Corridors, Restrooms, Stairs, and Support Areas
- Electrical, Mechanical, Telephone Rooms
- Laundry Rooms
- Locker/Dressing Room
- Parking Garage Areas
- Unoccupied Gross Floor Areas

2.5 Calculation Procedures

The general calculation procedure is illustrated below in Figure 2*. The* proposed design *TDV energy use* is compared *to the* standard design*.*

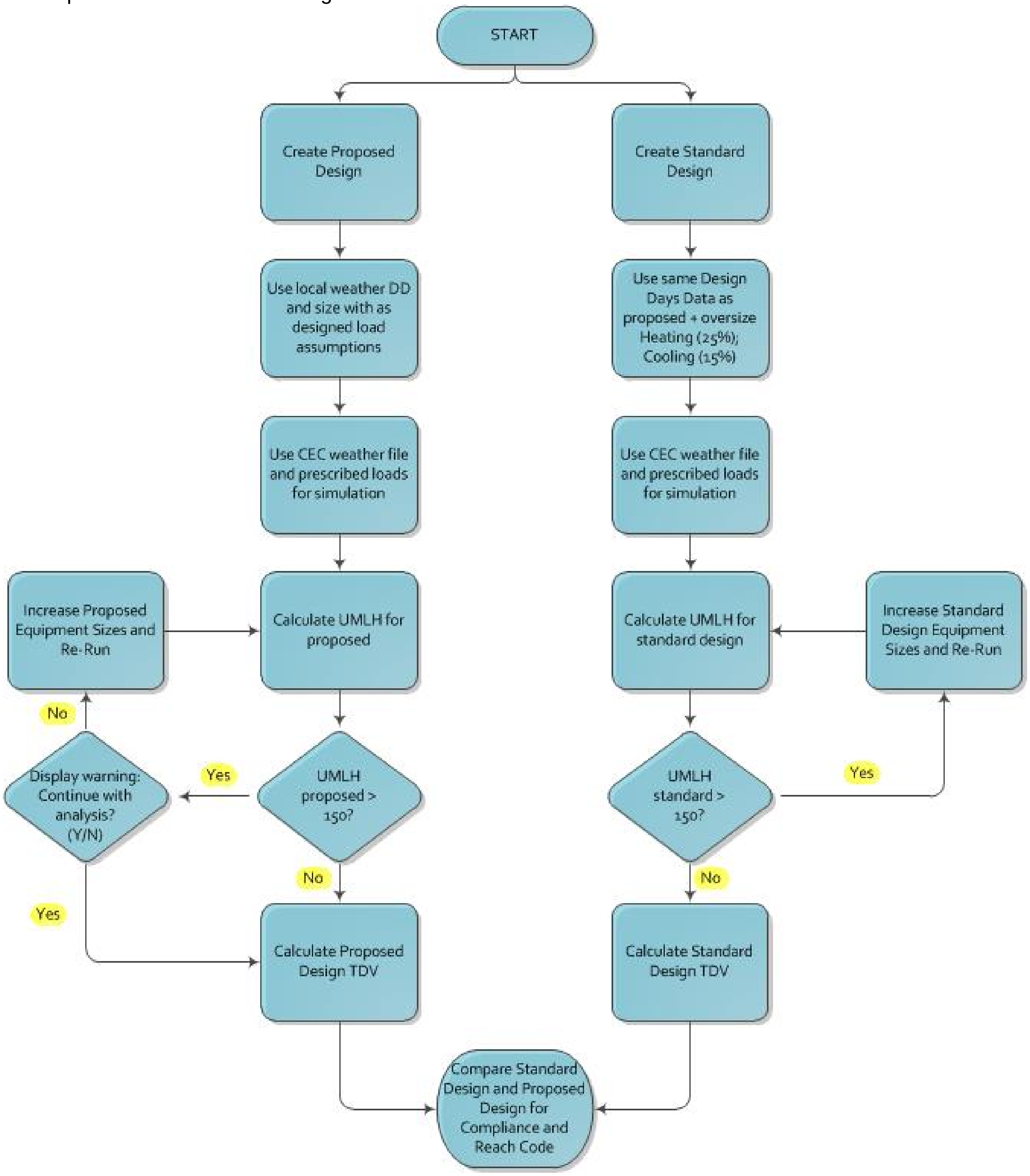


Figure 2 – Calculation Process for Title 24 Compliance and Reach Code

1. The process begins with a detailed description of the proposed design. Information is provided in enough detail to enable an estimate of annual energy use for a typical weather year. This information includes the building envelope, the lighting systems, the HVAC systems, the water heating systems and other important energy-using systems. This collection of information is referred to in this manual as *building descriptors*. Details on the building descriptors are provided in Chapter 5.
2. Before the calculations are performed, some of the building descriptors are modified for the proposed design to incorporate *prescribed* modeling assumptions. Prescribed modeling assumptions include occupant density, equipment power density, ventilation rates and water heating loads.
3. The next step is to make a simulation of the *proposed design* to determine how well the heating and cooling loads are being satisfied. The indicator is *unmet load hours*, the number of occupied hours during the year when the space temperature in one or more thermal zones is outside of the throttling range. A large number of hours indicate that the equipment is undersized.
4. Test the number of unmet load hours and proceed only if the hours for each zone in the building are less than or equal to 150 for the year of the proposed design simulation.
5. If the unmet load hours are greater than 150 for the year, then the proposed building simulation model is adjusted by the user to reduce the unmet load hours to less than or equal to 150, or the user has the option to continue with the simulation but the thermal zones that exceed 150 hours will be reported on the compliance form.. If the problem is heating, then the size of the boiler or furnace may need to be increased. If the problem is cooling, then the size of the coils or chillers may need to be increased. It is up to the designer to adjust equipment sizes as necessary; in some cases adjusting the zone airflows may solve the unmet load issue.
6. The final simulation is then performed to produce the results that are compared to the standard design, which is calculated in steps 7 through 16.
7. Create the standard design following the rules in this manual. The standard design has the same floor area, number of floors and spatial configuration as the proposed design; however, systems and components are modified to be in minimum compliance with the *standard design*. The HVAC systems for the standard design are established according to rules in this manual and depend on the primary building activity (residential or non-residential), the floor area, and the number of stories. See Section 5.1.
8. Sizing calculations are performed for the standard design and heating equipment is oversized by 25% and cooling equipment by 15%.
9. The standard design is simulated to determine the number of unmet load hours. This process is the same as performed for the proposed design in step 3.
10. The number of unmet load hours for the standard design is then tested to see if they are greater than 150 for any zone(s). This is not likely to occur since the heating and cooling equipment is oversized by 15% for cooling and 25% for heating in step 8.
11. If the unmet load hours in the standard design are greater than 150, then equipment capacity in the standard design is increased so that the unmet hours are less than or equal to 150. See the discussion below on how equipment sizes are increased.
12. Once the tests on unmet load hours are satisfied, then the energy consumption of the standard design is calculated. If the tests on unmet hours are satisfied the first time through, this step is the same as step 9.
13. Finally, the proposed design TDV energy use and standard design TDV energy use are compared for compliance or Reach.

2.6 HVAC Capacity Requirements and Sizing

To ensure that the simulated space-conditioning loads are adequately met, adequate capacity must be available in each of the components of the HVAC system; e.g., supply-air flow rates, cooling coils, chillers, and cooling towers. If any component of the system is incapable of adequate performance, the simulation may understate the required energy inputs for space conditioning and report unmet load hours. Adequate capacities are required in the simulations of both the proposed design and standard design. The subsections below describe the procedures that shall be followed to ensure that both versions of the design are simulated with adequate space-conditioning capacities.

2.6.1 Specifying HVAC Capacities for the Proposed Design

As shown in

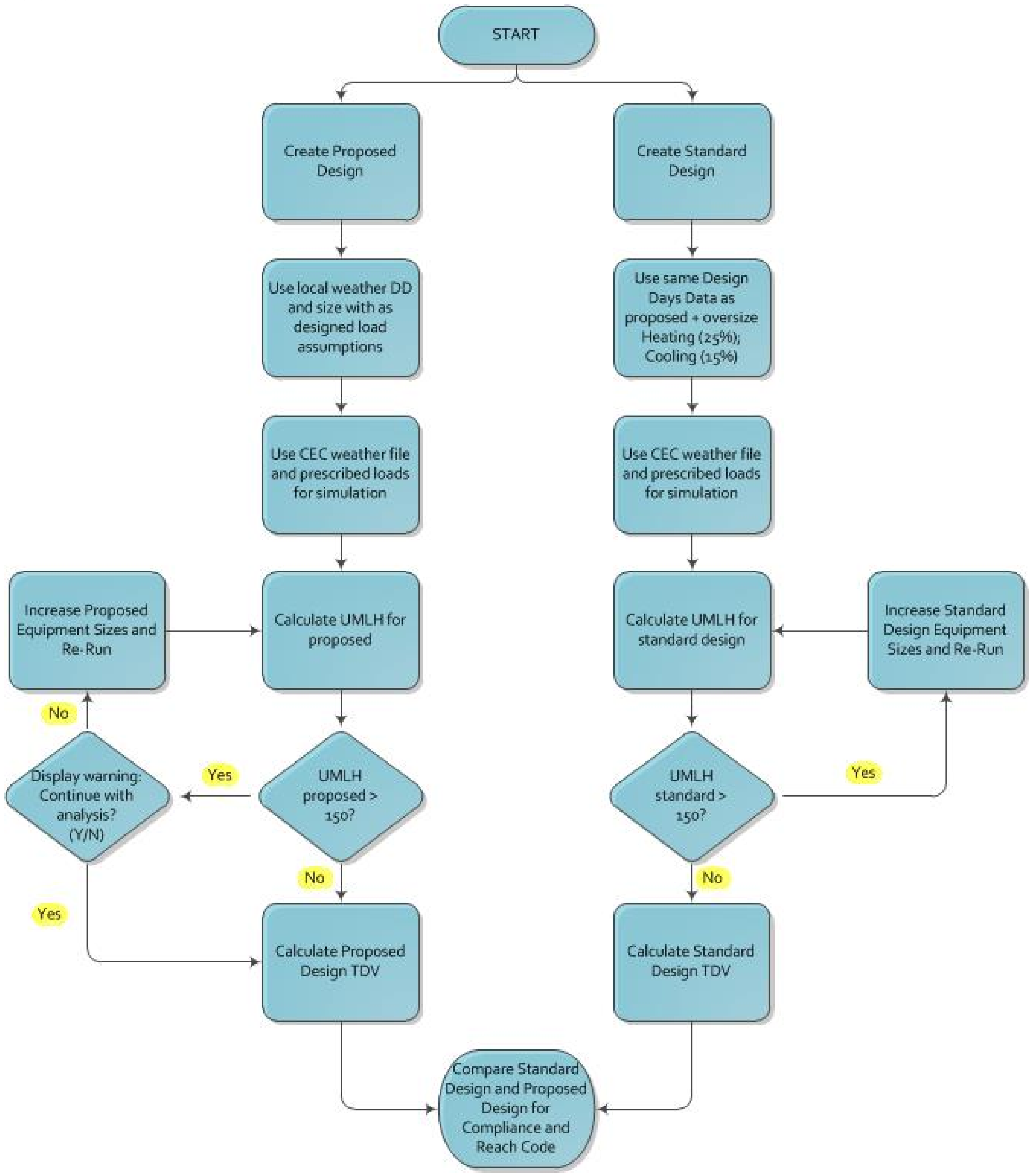


Figure 2, the proposed design should have no more than 150 unmet load hours. If this limit is exceeded, the software allows the user to make changes to the proposed design building description to bring the unmet load hours equal to or below 150. This process is not automated by the software. There are two tests that must be met to avoid excess unmet load hours:

- Space loads must be satisfied: Space temperatures in all thermal zones must be maintained within one half of the throttling range (1°F with a 2°F throttling range) of the scheduled heating or cooling thermostat setpoints. This criterion may be exceeded for no more than 150 hours for a typical year.
- System loads must be satisfied: Plant equipment must have adequate capacity to satisfy the HVAC system loads. This criterion may be exceeded for no more than 150 hours for a typical year.

If either the space or system loads do not meet the above criteria, the equipment in the proposed design shall be resized by the user such that the criteria are met. If the space conditioning criteria are not met because the HVAC equipment in the proposed design lacks the capability to provide either heating or cooling, equipment capable of providing the needed space conditioning must be specified by the user.

Equipment sizes for the proposed design shall be entered into the model by the energy analyst and shall agree with the equipment sizes specified in the construction documents. When the simulations of these actual systems indicate that specified space conditions are not being adequately maintained in one or more thermal zone(s), the user shall be prompted to make changes to equipment sizes or zones as necessary. This occurs when the unmet load hours exceed 150 for the year. The use of equipment sizes that do not match the actual equipment sizes as indicated on construction documents triggers an Exceptional Condition that is noted on the compliance forms.

2.6.2 Sizing Equipment in the Standard Design

For sizing heating and cooling equipment capacities, the compliance software shall use design day schedules as specified in Section 5.3. For cooling capacity sizing, compliance software shall use the OnDay schedule from Appendix 5.4B for occupant, lighting and equipment schedules, respectively. For heating capacity sizing, compliance software shall use the OffDay schedule from Appendix 5.4B for occupant, lighting and equipment schedules, respectively.

Equipment in the standard design is automatically oversized by the program (25% for heating and 15% for cooling). If the automatic oversizing percentage is not sufficient to meet demands, then Unmet load hours are evaluated at the building level by looking at the unmet load hours for each of the thermal zones being modeled. The zone with the greatest number of unmet load hours shall not exceed 150.

If the number of total unmet load hours for cooling and/or heating exceeds 150, then equipment capacities of cooling and/or heating equipment must be increased by the software incrementally.

1. The first step is to determine whether heating or cooling unmet load hours are the bigger problem. If heating unmet load hours are the bigger problem, upsize the heating equipment capacity. If cooling UMLH is the problem, upsize the cooling equipment capacity.
2. If the cooling is undersized, the equipment is resized by first increasing the design airflow of all zones with significant unmet load hours (greater than 150 for an individual zone) by 10%, then the equipment capacity for the system(s) serving the affected zones is increased to handle the increased zone loads. For a central plant the chiller(s) and towers are resized proportionally to handle the increased system loads.

If heating is undersized, the same procedure is followed, with zone terminal units resized first, then heating equipment second and then boilers as necessary.

The capacity of the boiler or furnace shall be increased in 5% increments and the simulation re-run until the loads are met. For heat pumps the capacity of the coil is increased so that the additional load is not met by auxiliary heat.

2.6.3 Handling Proposed Design with No HVAC Equipment

If a compliance model does not contain an HVAC system, if the number of unmet load hours exceeds 150 hours for any zone, then the compliance software shall prompt the user to enter a cooling capacity for an HVAC cooling system. The system type and efficiency characteristics shall match that of the standard design system. The compliance software shall make an appropriate note on compliance documentation indicating that the modeled HVAC system does not match design requirements. If the compliance software provides a means for the user that the building has no cooling system, then this information should be reported on the compliance reports or forms.

2.7 Ventilation Requirements

Design decisions regarding outside air ventilation shall be based on Section 120.1 of the Standards. If local codes do not apply, minimum values from Appendix 5.4A shall be used. Chapter 5.6 of the ACM has additional information on the ventilation requirements used in the building descriptors for the proposed and standard design. While no compliance credit can be claimed for reducing ventilation rates in the proposed design below the required levels, the user can specify higher ventilation rates in the proposed design.

3. Compliance Software Test Requirements

This chapter contains the procedures used to test and certify vendor's compliance software as acceptable for compliance with Title 24 Part 6. Compliance software must also follow all modeling rules specified in Chapter 5. The tests used to verify software functionality and accuracy of simulation results are referred to as the Reference Method. The tests fall into the following categories:

- Tests to verify that the software is evaluating thermal loads and the response of the HVAC systems to these loads in a manner that is acceptable. These tests reference *ASHRAE Standard 140-2007, Standard Method of Test for Evaluation of Building Energy Analysis Computer Programs*.
- Tests that verify that compliance software is capable of modeling envelope, lighting, HVAC and water heating efficiency features and provides precise estimates of energy tradeoffs and reasonably accurate predictions of building energy consumption.
- Tests to verify that the Standard Design (baseline building) is created correctly, e.g. that the baseline HVAC system is properly specified, that other components of the baseline are correctly defined and that rules that fix and restrict inputs (such as schedules and plug loads) are properly applied. These tests do not verify simulation outputs, but may require simulations to be run to specify inputs that are dependent on system sizing.
- The Reference Method is designed to cover representative software functionality for building envelope, space uses, lighting, daylighting, HVAC and water heating, both for simulation performance and for proper implementation of ACM rules specified in Chapter 5. The California Energy Commission reserves the right to add Ruleset Implementation Tests or Software Sensitivity Tests to verify existing or future compliance software requirements. Moreover, the California Energy Commission reserves the right to adjust the passing criteria for the Software Sensitivity Tests to reflect the capabilities of commonly available energy simulation programs.

3.1 General Requirements

3.1.1 Scope

The *Compliance Software* must satisfy the requirements contained in this section.

The *Compliance Software* shall be capable of modeling at least 50 *thermal zones*.

The *Compliance Software* shall be capable of modeling at least 15 separate HVAC systems.

3.1.2 Calculation Methods

The *Compliance Software* shall calculate the annual consumption of all end uses in buildings, including fuel and electricity for:

- HVAC (heating, cooling, fans, and ventilation);
- Lighting (both interior and exterior);
- Receptacles and miscellaneous electric;
- Service water heating;
- Process energy uses;
- Commercial refrigeration systems; and

- All other energy end uses that typically pass through the building meter.

The *Compliance Software* shall perform a simulation on an hourly time interval (at a minimum) over a one year period (8760 hours) with the ability to model changes in weather parameters, schedules, and other parameters for each hour of the year. This is achieved by specifying a 24-hour schedule for each day of the week plus holidays.

3.1.2.1 Calculating Design Loads

The software shall be capable of performing design load calculations for determining required HVAC equipment capacities and air and water flow rates using accepted industry calculation methods for the standard design.

3.1.2.2 Checking Simulation Output for Unmet Loads

The software shall be capable of checking the output of the energy analysis module for the proposed design to ensure that space conditions are maintained within the tolerances specified (maximum of 150 thermal zone unmet load hours per year).

3.1.2.3 Adjusting Capacities

For the baseline building, the software shall be capable of modifying capacities, temperatures or flow rates for baseline building HVAC system components causing excessive unmet load hours according to the procedures in Chapter 2.

3.1.2.4 Error Handling

The software shall send a warning to the user when unmet loads exceed 150 hours, , and provide information to the user describing the error that has occurred and what steps the user should take to remedy the situation.

3.1.3 Climate Data

The *Compliance Software* shall perform simulations using the official California Energy Commission weather files and design conditions documented in Joint Appendix 2.

The *Compliance Software* shall calculate solar radiation on exterior surfaces on an hourly basis from the values of direct normal irradiance and diffuse horizontal irradiance contained in the climate data, taking ground reflectance into account.

3.1.5 Time Dependent Valued (TDV) Energy

The Compliance Software shall be capable of applying the Energy Commission TDV multipliers for each hour of the simulation. See California Energy Commission Joint Appendix 3.

3.1.6 Thermal Mass

The calculation procedures used in the *Compliance Software* shall account for the effect of thermal mass on loads due to occupants, lights, solar radiation, and transmission through building envelope, on the amount of heating and cooling required to maintain the specified space temperature schedules; and on variation in space temperature.

3.1.7 Modeling Space Temperature

The *Compliance Software* shall incorporate a dynamic simulation of space temperature which accounts for:

- Dynamics in change in heating and cooling setpoint temperatures;
- Deadband between heating and cooling thermostat settings;
- Temperature drift in transition to setback or setup thermostat schedules;
- Temperature drift in periods when heating or cooling capability are scheduled off;
- Temperature drift when heating or cooling capability of the system is limited by heating or cooling capacity, air flow rate, or scheduled supply air temperature; and
- Indirectly conditioned *thermal zones*, where the temperature is determined by internal loads, heat transfer through building envelope, and heat transfer between *thermal zones*.

3.1.8 Heat Transfer between Thermal zones

The *Compliance Software* shall be capable of modeling heat transfer between a *thermal zone* and adjacent *thermal zones*.

The *Compliance Software* shall account for the effect of this heat transfer on the space temperature, space conditioning loads, and resulting energy use in the *thermal zone* and in the adjacent *thermal zones*.

3.1.9 Control and Operating Schedules

The *Compliance Software* shall be capable of modeling control and operating schedules which can vary by:

- The hour of the day;
- The day of the week; and
- Holidays treated as a special day of the week.

The *Compliance Software* shall be capable of explicitly modeling all of the schedules specified in Appendix 5.4B of this manual.

3.1.10 Loads Calculation

The load calculations described in this section relate to the simulation engine and not to the procedure used by the design engineer to size and select equipment.

3.1.10.1 Internal Loads

The *Compliance Software* shall be capable of calculating the hourly cooling loads due to occupants, lights, receptacles, and process loads.

The calculation of internal loads shall account for the dynamic effects of thermal mass.

The *Compliance Software* shall be capable of simulating schedules for internal loads in the form given in Appendix 5.4B.

The simulation of cooling load due to lights shall account for:

- The effect of the proportion radiant and convective heat, which depends on the type of light, on the dynamic response characteristic; and
- A portion of heat from lights going directly to return air, the amount depending on the type and location of fixture.

3.1.10.2 Building Envelope Loads

The *Compliance Software* shall calculate heat transfer through walls, roofs and floors for each *thermal zone*, accounting for the dynamic response due to thermal characteristics of the particular construction as defined in the *Building Descriptors* in Chapter 5.

The calculation of heat transfer through walls and roofs shall account for the effect of solar radiation absorbed on the exterior surface, which depends on orientation and absorptance of the surface.

The *Compliance Software* shall calculate heat transfer through windows and skylights, accounting for both temperature difference and transmission of solar radiation through the glazing.

Calculation of cooling load due to transmission of solar radiation through windows and skylights shall account for:

- The angular incidence of the direct beam sunlight and the angular and spectral dependence of the solar properties.
- The variation of thermal properties of the fenestration system with ambient temperature.
- Orientation (azimuth and tilt of surface).
- The effect of shading from overhangs, side fins, louvers or neighboring buildings or terrain.

3.1.10.3 Infiltration

The *Compliance Software* shall be capable of simulating infiltration that varies by the time of day and day of the week. Schedules are provided in Appendix 5.4B.

3.1.11 Systems Simulation

3.1.11.1 General

The *Compliance Software* shall be capable of modeling:

- The baseline building systems defined in Chapter 5,
- The lighting, water heating, HVAC and miscellaneous equipment detailed in Chapter 5
- All compulsory and required features as detailed in Chapter 5

The capability to model multiple zone systems shall allow at least 15 *thermal zones* to be served by one multiple zone system.

The *Compliance Software* shall be capable of modeling plenum air return.

3.1.11.2 HVAC Zone Level Systems

The *Compliance Software* shall be capable of simulating the effect on space temperature and energy use of:

- Limited capacity of terminal heating devices;
- Limited capacity of terminal cooling devices; and

- Limited rate of air flow to *thermal zone*s.

3.1.11.3 HVAC Secondary Systems and Equipment

The *Compliance Software* shall be capable of simulating the effect on energy use and space temperature in *thermal zones* served by the HVAC system of:

- Limited heating capacity of an HVAC system; and
- Limited cooling capacity of an HVAC system.

The simulation of HVAC systems shall account for:

- Temperature rise of supply air due to heat from supply fan, depending on the location of the fan;
- Temperature rise of return air due to heat from return fan;
- Temperature rise of return air due to heat from lights to return air stream; and
- Fan power as a function of supply air flow in variable air volume systems.

3.1.11.4 HVAC Primary Systems and Equipment

The *Compliance Software* shall be capable of simulating the effect on energy use of limited heating or cooling capacity of the central plant system.

If the *Compliance Software* is not capable of simulating the effect of limited heating or cooling capacity of the central plant system on space temperature in *thermal zones* dependent on the central plant system for heating and cooling, then it shall issue a warning message when loads on the central plant system are not met.

3.1.11.5 Equipment Performance Curves

The *Compliance Software* shall be capable of modeling the part load efficiency and variation in capacity of equipment as follows:

- Furnaces as a function of part load;
- Boilers as a function of part load, supply hot water temperature, and return hot water temperature;
- Water-cooled compressors including heat pumps and chillers as a function of part load, evaporator fluid, or air temperature and condensing fluid temperature;
- Air-cooled compressors including heat pumps, direct expansion cooling and chillers as a function of part load, ambient dry-bulb temperature, and wet-bulb temperature returning to the cooling coil;
- Evaporative cooling systems as a function of ambient wet-bulb temperature; and
- Cooling towers as a function of range and ambient wet-bulb temperature.

3.1.11.6 Economizer Control

The *Compliance Software* shall be capable of modeling integrated air- and water-side economizers.

3.1.11.7 Heat-Recovery Water Heating

The Compliance Software shall be capable of modeling heat recovery water heating from the following sources:

- Double bundled chiller;

- Refrigerant desuperheater as part of a packaged HVAC unit;
- Heat exchanger on the condenser water loop; and
- Heat-recovery water-to-water heat pumps operating off of the condenser or chilled water loop.

3.2 Special Documentation and Reporting Requirements

3.2.1 Building Envelope

3.2.1.1 Roof Radiative Properties

The user shall enter three-year aged roof reflectance and emittance for roofs that have been certified by the Cool Roof Rating Council. The software shall report the product identification number(s) of any roofing products used on the building, so that aged reflectance and emittance can be verified by the code official.

3.2.2 Interior Lighting

3.2.2.1 Regulated Interior Lighting Power

Complete lighting plans and space plans are required for the tailored method. Prescriptive compliance forms for the tailored method shall be developed and these shall be verified by the plans examiner.

Whenever any of the special allowance exceptions (footnotes in Standards Table 140.6-C) are claimed, the compliance software shall make an entry on the compliance forms to indicate that verification is required.

With the tailored lighting method, the software shall make an entry in the special features section on the California compliance forms that the tailored lighting method has been used to determine the lighting power for this space and that all necessary prescriptive tailored lighting forms and worksheets documenting the lighting and its justification shall be provided as part of the compliance documentation and be approved independently.

3.2.2.2 Indoor Lighting Power (see 5.4.4)

Compliance software shall print all applicable lighting forms and report the lighting energy use and the lighting level (Watts/ft^2) for the entire project. Compliance software shall report “No Lighting Installed” for nonresidential spaces with no installed lighting. Compliance software shall report “Default Residential Lighting” for residential units of high rise residential buildings and hotel/motel guest rooms.

If the modeled Lighting Power Density (LPD) is different than the actual LPD calculated from the fixture schedule for the building, Compliance software shall model the larger of the two values for sizing the mechanical systems and for the compliance run. Compliance software shall report the larger value on PRF-1. Lighting levels schedules shall be adjusted by any lighting Control Credit Watts, if input by the user.

Lighting power is not modeled in unconditioned spaces that are modeled, but lighting in those spaces is required to meet the prescriptive requirements for regulated unconditioned spaces such as commercial and industrial storage spaces and parking garages. When these types of spaces are entered the compliance software must report in the Special Features section that these spaces must comply with the prescriptive requirements for such spaces.

3.2.2.3 Complete Building Method

The Complete Building method triggers special reporting requirements. The compliance software shall report the following on the compliance form:

"The Complete Building method requires that at least 90% of the building contain conditioned space, and that at least 90% of the building conform to the building type classification. This condition must be verified by the building official."

3.2.2.4 Design Illumination Setpoint

Spaces that have low design illuminance levels, below the ranges specified in Appendix 5.4A, shall provide documentation that show the design illuminance to be used as the daylight illumination setpoint.

3.2.3 Exterior Lighting

If the lighted façade area exceeds exterior wall area or if door linear footage exceeds 25% of building perimeter, the software shall produce a warning.

3.2.4 HVAC Exceptional Conditions

3.2.4.1 Equipment Sizing

When any proposed equipment size for secondary equipment or central plant equipment does not match the equipment size listed on construction documents, an exceptional condition shall be reported on compliance forms.

3.2.4.2 Equipment Performance Curves

An exceptional condition must be noted if the user enters performance data for DX equipment greater than 135,000 Btu/h.

For equipment with a capacity less than or equal to 135,000 Btu/h, but larger than 65,000 Btu/h, the user may not enter data on the temperature dependent equipment performance. However, the compliance software vendor may work with manufacturers to collect such data and build this data into the compliance software. The user may either select equipment for which the compliance software vendor has collected or use the defaults.

3.2.4.3 Process and Filtration Pressure Drop Allowance

Any non-zero value entered for supply fan process and filtration pressure drop shall be flagged as an exceptional condition in the compliance documentation. An allowance of up to 1" w.g. is provided in the static pressure for process and filtration requirements (such as clean rooms). Any amount may be claimed for the proposed building, but the standard design (baseline) is adjusted by a maximum of 1" w.g.

3.2.4.4 Natural Ventilation Specified

Any time natural ventilation is specified by the user for the proposed design, either for residential or nonresidential spaces, the software shall report an exceptional condition, that the exception in section of the 120.1 of the Standards must be met:

```
1. Natural ventilation.

A. Naturally ventilated spaces shall be permanently open to and within 20 feet of
operable wall or roof openings to the outdoors, the openable area of which is not less
than 5 percent of the conditioned floor area of the naturally ventilated space. Where
openings are covered with louvers or otherwise obstructed, openable area shall be
based on the free unobstructed area through the opening.

EXCEPTION to Section 120.1(b)1A: Naturally ventilated spaces in high-rise residential
dwelling units and hotel/motel guest rooms shall be open to and within 25 feet of
operable wall or roof openings to the outdoors.

B. The means to open required operable openings shall be readily accessible to
building occupants whenever the space is occupied.
```

3.3 ASHRAE Standard 140-2007 Tests

This method of testing is provided for analyzing and diagnosing building energy simulation software using software-to-software and software-to-quasi-analytical-solution comparisons. The methodology allows different building energy simulation programs, representing different degrees of modeling complexity, to be tested by comparing the predictions from other building energy programs to the simulation results provided by the Compliance Software in question.

Compliance software must pass ASHRAE 140-2007 tests, but these tests are not part of the Reference Method.

3.4 Ruleset Implementation Tests

3.4.1 Introduction

The tests in this section are intended to verify that the software correctly constructs the Standard Design model and applies rules of the 2013 Nonresidential ACM appropriately to the proposed and Standard Design models. The rule set implementation tests cover representative portions of the rules for building envelope, lighting, daylighting, space use data and HVAC. For each test there is a set of three models defined:

- User Model – the user model contains the user inputs for the as-designed building. In most cases, the values for the Proposed Design will be taken from user inputs with no modification. However, there are some cases where the building input is prescribed for the Proposed Design, or constrained by mandatory minimums or other rules.
- Proposed Design Model – the proposed model is defined by the rules in the ACM Reference Manual and created by the vendor software and is the building modeled for compliance. This model takes user inputs for building geometry, building envelope, lighting and HVAC and is used in the compliance simulation.
- Standard Design Model – this is the baseline model defined by the ACM Reference Manual modeling rules, and is the basis for comparison that determines whether a building passes compliance using the performance method.

These tests do not require that simulation outputs be verified, but they do require that simulation input files for the Proposed Design and Standard Design are properly constructed according to the rules in the ACM Reference Manual. Some tests require that sizing runs be performed, for HVAC inputs whose values are dependent on autosized Standard Design systems.

3.4.2 Overview

The test runs described in this section represent the Title-24 2013 Non-Residential ACM code compliance calculation and use the following Prototype Models- Small Office Building, Medium Office Building, Large Office Building, Warehouse Building and Small Hotel. For further details on the Prototype Models, refer to Appendix 3C. Each of the Standard Design test cases shall be created by modifying the Prototype Model as described in Section IV of this document. The modified Prototype Model shall form the proposed case for each test run. The Standard Design model shall be generated by compliance software as per the rules in the 2013 Nonresidential ACM. The Standard Design and proposed model files for each test case shall then be evaluated to verify that:

- The Standard Design building envelope constructions are correctly substituted for exterior opaque surfaces and fenestrations.
- Fenestration area in the Standard Design building is reduced in accordance with the 2013 Nonresidential ACM Manual, when the Proposed Design fenestration area is greater than 40% of the exterior wall.
- Skylight area in the Standard Design building is adjusted in accordance with the 2013 Nonresidential ACM Manual, when applicable.
- Default schedules of operation are applied for both the Standard Design building and the Proposed Design.
- The Proposed and Standard Design cases use the same defaults or tailored inputs for internal loads as required by the 2013 Nonresidential ACM Manual.
- The Standard Design building lighting system is correctly specified and that exterior lighting is modeled.
- Receptacle loads and process loads are modeled according to the rules in the 2013 Nonresidential ACM Manual.
- The Standard Design building uses the correct system types as prescribed in Table 5 of the 2013 Nonresidential ACM Manual.
- An economizer (of the right type) is included in the Standard Design building if required.
- The primary and secondary Standard Design building systems are properly specified and sized.
- Fan brake horsepower is correctly specified for the Standard Design building.
- Prescribed modeling assumptions are applied for both the Standard Design building and the Proposed Design.
- Overhangs are modeled in the Proposed Design for Test Case 7 but not the Standard Design building.
- Unconditioned spaces are modeled.
- Other Standard Design building specifications and/or modeling assumptions are correctly applied. As the software developer verifies the various test conditions, the input and output files should be annotated with comments or other methods to demonstrate that the modeling rules specified in the 2013 Nonresidential ACM Manual are correctly applied. Software developers should use the spreadsheets included in Appendix 3C, to report the results of these tests. These annotated files shall then be submitted to the Commission for further evaluation. Any errors discovered shall be corrected by making modifications to the software; the runs shall be repeated; and the new results shall be annotated for submittal to the Commission.

The Standard Design Tests are labeled using the format:

(S) 0200CZ-OffSml- Run01

Run Number
Prototype Name
Climate Zone
Prototype Number
S-Simple Geometry, D-Detailed Geometry

3.4.3 Ruleset Implementation Tests

The following tests shall be performed to verify that the compliance software correctly creates the Standard Design model and applies modeling rules as per the requirements of the 2013 Nonresidential ACM. The user model shall be created by modifying the appropriate Prototype Model type. The Standard Design Model for each test case shall be generated automatically by the complaince software.

The characteristics of the user model and inputs to be verified in the Proposed and Standard Design models are described below.

1. (D/S) 020006-OffSml-Run01– This test will verify that the applicant software models the wall, floor and roof construction correctly and that the envelope and fenestration performance requirements for the Standard Design are modelled as per the requirements of 2013 Nonresidential ACM.
   The user model is a small office building in climate zone 6 with the following envelope characteristics:
   - Steep slope, wood frame roof with assembly U-value of 0.044, Aged Solar Reflectance of 0.75 and Thermal emittance of 0.78
   - Wood-framed wall with assembly U-value of 0.091
   - Exterior soffit floor with assembly U-factor of 0.070
   - Mass floor with asssembly U-value of 0.039
   - Fixed window with U-factor of 0.25, SHGC of 0.20 and VT of 0.45

   The following inputs in the Proposed Design and Standard Design model file shall be verified and reported in the output form provided in Appendix 3C:
   - Standard Design roof, wall and floor construction assembly type
   - Standard Design roof, wall and floor overall U-value
   - Standard Design roof, wall and floor construction assembly layer inputs
   - Standard Design roof aged solar reflectance and thermal emittance
   - Window U-factor, SHGC and VT
2. (D/S) 020015-OffSml-Run02– This test will verify that the applicant software models the wall, floor, roof construction and fenestrations correctly and that the envelope performance requirements for the Standard Design are modelled as per the 2013 Nonresidential ACM.
   The user model is a small office building in climate zone 15 with the following envelope characteristics:
   - Steep sloped wood frame roof with assembly U-factor of 0.053, Aged Solar Reflectance of 0.60 and Thermal emittance of 0.70
   - Metal-framed wall with assembly U-factor of 0.056
   - Exterior soffit floor with assembly U-factor of 0.070
   - Slab on grade floor with floor F-factor of 0.70
   - Horizontal overhang of 2 feet on south facing windows and vertical fins of 2 feet on right of west facing windows

   The following inputs in the Proposed Design and Standard Design model file shall be verified and reported in the output form provided in Appendix 3C:
   - Standard Design roof, wall and floor construction assembly type
   - Standard Design roof, wall and floor construction assembly layer inputs
   - Standard Design roof, wall and floor overall U-value
   - Standard Design floor slab F-factor
   - Standard Design roof aged solar reflectance and thermal emittance.
   - Window overhangs for south and west windows

3. (D) 070015-HotSml-Run03 – This test will verify that the applicant software models the wall, floor and roof construction correctly and that the envelope and fenestration performance requirements for the Standard Design are modelled as per the requirements of 2013 Nonresidential ACM.
   The user model is a small hotel building in climate zone 15 with the following characteristics:
   - Horizontal Metal frame Roof with assembly U-value of 0.055, Aged Solar Reflectance of 0.60 and Thermal emittance of 0.70
   - Metal-framed wall with assembly U-value of 0.082
   - Mass Floor with assembly U-value of 0.058
   - Fixed windows in the first floor with U-factor of 0.25, RSHGC of 0.20 and V.T of 0.47
   - Operable windows in guest room windows with U-factor of 0.42, SHGC of 0.18 and VT of 0.35

   The following inputs in the Standard Design model file shall be verified and reported in the output form provided in Appendix 3C:
   - Standard Design roof, wall and floor construction assembly type
   - Standard Design roof, wall and floor construction assembly layer inputs
   - Standard Design roof, wall and floor U-value
   - Standard Design roof aged solar reflectance and thermal emittance.
   - Window U-value, SHGC and VT
4. (D/S) 030006-OffMed-Run04 – This test will verify that mandatory minimum opaque envelope insulation requirements are applied. The user model is a small office building in climate zone 6, with a metal-framed wall containing R-5 continuous insulation on the exterior and a U-factor of 0.136.
   a. For this test, the user model should be ***undefined***, and the compliance simulation should not run.
5. (D) 040006-OffLrg-Run05 – Run 05 tests whether the applicant software determines the window area of the Standard Design model as per the rules in 2013 Nonresidential ACM.
   The user model is the Large office building in climate zone 6 with an overall window-to-wall ratio (WWR) of 52% made of a continuous band of glass distributed evenly across all facades.

   The following inputs in the Proposed Design and Standard Design model file shall be verified and reported in the output form provided in Appendix 3C:
   - WWR
6. (D) 040006-OffLrg-Run06 – Run 06 tests whether the applicant software determines the window area of the Standard Design model as per the rules in 2013 Nonresidential ACM.
   The user model is the Large office building in climate zone 6 with overall building WWR-46% and 50% WWR in the west, 40% in South, 45% in East and 50% in the North façade.

   The following inputs in the Proposed Design and Standard Design model file shall be verified and reported in the output form provided in Appendix 3C:
   - Window Area (and WWR) for each orientation
   - Window Area (and Overall WWR) for the building
7. (D) 080006-Whse-Run07 – This test verifies whether the applicant software models the Standard Design skylight as per the performance requirements for skylights in 2013 Nonresidential ACM. This test checks whether the applicant software determines the skylight area of the Standard Design model correctly.
   The user model is a Warehouse building in climate zone 6 with an overall skylight-to-roof ratio (SRR) of 7%. Curb mounted glass Skylight with U-value 0.55, SHGC 0.20 and VT 0.40. The building has ceiling heights of 28 feet in the warehouse and 14 feet in the office.

   The following inputs in the Standard Design model file shall be verified and reported in the output form provided in Appendix 3C:
   - Skylight U-factor, SHGC and VT, and SRR

8. (D) 080006-Whse-Run08 – This test checks whether the applicant software determines the skylight area of the Standard Design model correctly.
   The user model is a Warehouse building in climate zone 6 with ceiling heights of 28 feet in the warehouse and 14 feet in the office.The SRR of the proposed building is 14% and 80% of the building area gets daylighting from skylights or sidelights.

   The following Standard Design inputs shall be verified:
   - Standard Design SRR, Standard Design total daylit area as a fraction of gross building area
9. (D) 080006-Whse-Run09 – This test checks whether the applicant software determines the skylight area of the Standard Design model correctly.
   The user model is a Warehouse building in climate zone 6 with ceiling heights of 28 feet 14 feet in the office. The SRR of the proposed building is 5% and 55% of the building area gets daylighting from skylights or sidelights.

   The following Standard Design inputs shall be verified and reported in the output form provided in Appendix 3C:
   - Standard Design SRR, Standard Design total daylit area as a fraction of gross building area
10. (D) 030006-OffMed-Run10 – This test verifies whether the applicant software inserts the correct Standard Design inputs for schedules, occupant density, equipment power density, lighting power density, hot water load and ventilation rates using the Complete Building lighting method and in accordance with 2013 Nonresidential ACM. The user model is an office occupancy with:
    - Occupant Density- 50 ft^2/person
    - Equipment Power Density- 3 W/ft^2
    - Lighting Power Density- 1.2 W/ft^2
    - Hot Water Load- 106 Btu/person
    - Ventilation Rate- 0.15 cfm/ft^2

    The Proposed Design and Standard Design Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:
    - Schedules (verified shall include occupancy schedule, lighting schedule, receptacle schedule, hot water schedule, infiltration schedule and elevator schedule)
    - Occupant Density
    - Equipment Power Density
    - Lighting Power Density
    - Hot Water Load
    - Ventilation Rate
11. (D) 040006-OffLrg-Run11 – This test verifies whether the applicant software inserts the correct Proposed Design and Standard Design inputs for schedules, occupant density, equipment power density, lighting power density, hot water load and ventilation rates in accordance with 2013 Nonresidential ACM. This run tests the capability of the applicant software to model Standard Design inputs for multiple space types using the Area Category lighting method.
    The user model is the Large office building in climate zone six with the following characteristics:
    - First Floor
      <u>Core and North, West Perimeter Zones</u> - Retail Merchandise Sales, Wholesale Showroom- Occupant Density 33 ppl/1000ft^2, EPD-2W/ft^2, LPD-1W/ft^2, Ventilation rate- 0.75 cfm/ft^2, Hot Water Load- 0.18 gal/person/hr.
      <u>East Perimeter Zone</u> – Corridors, Restrooms, Stairs and Support Areas - Occupant Density 10 ppl/1000ft^2, EPD-0.2W/ft^2, LPD-0.5W/ft^2, Ventilation rate- 0.15 cfm/ft^2 , Hot Water Load- 0 gal/person/hr.

South Perimeter Zone – Lobby, Main Entry - Occupant Density 67 ppl/1000ft^2, EPD-0.5W/ft^2, LPD-1.5W/ft^2, Ventilation rate- 1.0 cfm/ft^2. , Hot Water Load- 0.09 gal/person/hr

- Second to Sixth Floor
  Core and South, West, North Perimeter Zones - Medical and Clinical Care- Occupant Density 10 ppl/1000ft^2, EPD-1.5 W/ft^2, LPD-1W/ft^2, Ventilation rate- 0.15 cfm/ft^2, Hot Water Load- 0.24 gal/person/hr
  East Perimeter Zone – Corridors, Restrooms, Stairs and Support Areas - Occupant Density 10 ppl/1000ft^2, EPD-0.2W/ft^2, LPD-0.5W/ft^2, Ventilation rate- 0.15 cfm/ft^2, Hot Water Load- 0 gal/person/hr.
- Seventh to Eleventh Floor Core zones
  Core and South, West, North Perimeter Zones - Office (Greater than 250 swaure feet in floor area)- Occupant Density 10 ppl/1000ft^2, EPD-1.5 W/ft^2, LPD-0.75W/ft^2, Ventilation rate- 0.15 cfm/ft^2, Hot Water Load- 0.18 gal/person/hr
  East Perimeter Zone – Corridors, Restrooms, Stairs and Support Areas - Occupant Density 10 ppl/1000ft^2, EPD-0.2W/ft^2, LPD-0.5W/ft^2, Ventilation rate- 0.15 cfm/ft^2, Hot Water Load- 0 gal/person/hr.
- Twelfth Floor Core zones
  Core and South, West, North Perimeter Zones – Convention, Conference, Multipurpose and Meeting Center- Occupant Density 67 ppl/1000ft^2, EPD-1W/ft^2, LPD-1.2W/ft^2, Ventilation rate- 1 cfm/ft^2, Hot Water Load- 0.09 gal/person/hr
  East Perimeter Zone – Corridors, Restrooms, Stairs and Support Areas - Occupant Density 10 ppl/1000ft^2, EPD-0.2W/ft^2, LPD-0.5W/ft^2, Ventilation rate- 0.15 cfm/ft^2 Hot Water Load- 0 gal/person/hr.

For each space type, the Proposed Design and Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:

- Schedules (verified shall include occupancy schedule, lighting schedule, receptacle schedule, hot water schedule, infiltration schedule and elevator schedule)
- Occupant Density
- Equipment Power Density
- Lighting Power Density
- Ventilation Rate

12. (D) 030006-OffMed-Run12 – This test verifies if the applicant software applies the requirements of the Tailored Lighting Method appropriately.
    The User Model is a medium office building in climate Zone 6 with the following characteristics:
    - Perimeter zones on all floors are modelled as main entry spaces using the Tailored Lighting Method. The space has a general lighting of 0.5 W/ft^2
    - Core zones on all floors are modelled as waiting spaces using the Tailored Lighting Method. The space has a general lighting of 0.75 W/ft^2 and ornamental lighting of 0.2 W/ft^2

    For each space type, the Proposed Design and Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:
    - Lighting Power Density for main entry area
    - Lighting Power Density General Lighting Power for waiting area
    - Lighting Power Density Custom Lighting Power for waiting area
    - Lighting Schedules
13. (D) 030006-OffMed-Run13 – This test verifies if the applicant software applies the requirements of the Tailored Lighting Method appropriately.
    The user model is a medium office building in climate Zone 6 with the following chracteristics:

- Perimeter zones on all floors are modelled as main entry spaces using the Tailored Lighting Method. The space has a general lighting of 0.8 W/ft^2 and task lighting of 0.1 W/ft^2
- Core zones on all floors are modelled as waiting spaces using the Tailored Lighting Method. The space has a general lighting of 0.6 W/ft^2, floor display lighting of 0.1 W/ft^2, and ornamental lighting of 1.2 W/ft^2

For each space type, the Proposed Design and Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:

- Lighting Power Density for main entry area
- Lighting Power Density General Lighting Power for waiting area
- Lighting Power Density Custom Lighting Power for waiting area
- Lighting Schedules

14. (D/S) 020006-OffSml-Run14 – This test verifies if the applicant software models lighting power density and schedules for eligible Califonia Power adjustment factors as required by the 2013 Nonresidential ACM.

    The user model is a small office building (area=5500 sq ft) with demand responsive lighting controls. The model files shall be examined to verify whether adjustment factors are applied as per the requirements in the 2013 Nonresidential ACM.

    For this test, the lighting power density of the proposed model and Standard Design are verified and reported in the output form provided in Appendix 3C:

    - Lighting Power Density
    - Lighting Schedules

15. (D) 080006-Whse-Run15 – This test verifies the ability of the applicant software to model daylighting controls as per the requirements of the 2013 Nonresidential ACM.

    The user model is a warehouse building in CZ-6 with the following characteristics:

    - The building has three spaces – Office, Fine Storage and Bulk Storage. The office space gets daylighting from four windows. Fine Storage and bulk storage get daylighting from skylights.
    - Daylighting controls are installed in primary side daylit areas of the office and skylit daylit areas in all storage spaces.
    - The installed general lighting power controlled by daylight controls in the office space is 150 Watts. The installed lighting power in the primary daylit zone is 150 Watts and the installed lighting power in the secondary daylit zone is 0 Watts.
    - The primary side daylighting illuminance setpoint for the office spaces is set at 400 lux and the skylit daylighting illuminance setpoint in the fine storage and bulk storage are each set at 250 lux.

    The Proposed Design and Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:

    For the office space primary daylit zone and secondary daylit zone:

    - Lighting Power in Daylit Zone – for this input, the lighting power for general lighting is assumed to be uniform throughout the space for the Standard Design, so the fraction of lighting power in the space in the primary daylit zone and secondary daylit zone is equal to the fraction of space floor area that is in the primary daylit zone
    - Secondary Daylit Zone Adjustment Factor – by space type, from Appendix 5.4A
    - Daylight control type
    - Reference position and illuminance setpoint

    For the bulk storage space:

    - Lighting Power in the Daylit Zone

- Daylight control type
- Reference position and illuminance setpoint
- For the fine storage space:
- Lighting Power in the Daylit Zone
- Daylight control type
- Reference position and illuminance setpoint

16. (D) 050006-RetlMed-Run16 – This test verifies the ability of the applicant software to model daylighting controls as per the requirements of the 2013 Nonresidential ACM.
    The user model is a retail building in CZ-6 with the following characteristics:
    - The building has five spaces – Front Entry, Point of Sale, Front Retail, Core Retail and Back Space. The front retail space has daylighting from 5 feet high glass on the exterior with a sill height of 3.74 ft. This test only tests the daylighting control in the front retail space.
    - Daylighting controls are installed in primary and skylit daylit areas in all spaces and in the secondary daylit area of the Bulk Storage.
    - The front retail space has a general lighting power of 1.6 W/ft^2 and task and floor display accent lighting in the space of 0.75 W/ft^2 in the front half of the space closest to the exterior window.
    - The illuminance setpoint in all daylit spaces is set at 950 lux in all daylit spaces except for the Front_Entry Space which is at 200 lux..
    - The reference position for the front retail space is 5 feet from the exterior wall, at the midpoint between the two interior walls, for the primary daylit zone, and 12 feet from the exterior wall, at the midpoint between the two interior walls, for the secondary daylit zone.

    The Proposed Design and Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:

    For the front retail space, primary daylit zone and secondary daylit zone:
    - Lighting Power Density, General Lighting – this is calculated from the room cavity ratio and illuminance level
    - Lighting Power in Daylit Zone – this input defines the lighting power that is controlled by daylight dimming controls
    - Secondary Daylit Zone Adjustment Factor – by space type, from Appendix 5.4A
    - Daylight control type
    - Reference position and illuminance setpoint
17. (D) 040006-OffLrg-Run17 – This test verifies if the 2013 Nonresidential ACM rules for exterior lighting are applied accurately for exterior lighting power, exterior lighting control and schedules. This test also verifies if the Service Hot Water systems are modelled correctly.
    The user model is a large office building in climate zone 6, with the following characteristics:
    - Hot water load of 106 Btu/h-person
    - Thermal efficiency of 0.78
    - An exterior hardscape comprising of:
        i. Driveway of dimensions 20x30 feet with lighting load of 1115 Watts
        ii. Parking lot of dimensions 180x56 feet with lighting load of 6566 Watts
        iii. 2 sidewalks of dimensions 6x30 feet with total lighting load of 977 Watts
        iv. A building entrance door light of 90 Watts.
        v. 50 square feet of hardscape ornamental light of 2 Watts
        vi. Lighting load of 6566 Watts on the building façade.
        vii. Signage of 40 square feet with lighting load of 80 Watts

    This test verifies that the Proposed Design and standard design are specified correctly for:

- Service Water Heating: thermal efficiency, hot water load
- Exterior Lighting Power

18. (D/S) 020006-OffSml-Run18 – This test checks if the applicant software models the Standard Design HVAC system in accordance with the requirements of the 2013 Nonresidential ACM. The user model is a small office building in climate zone 6 with the following characteristics:
    - DX cooling
    - SEER – 17.58 (Cooling COP-3.84, EER 13.1)
    - Gas Furnace Heating
    - 78% AFUE (Thermal Efficiency – 80%)
    - Constant Volume Fan

    The following Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:
    - HVAC System Type
    - Heating and Cooling Type
    - Heating and Cooling Efficiency
    - System Sizing
    - Maximum and minimum supply air temperature
    - Fan Control Method
    - Cooling and heating efficiency curve
    - Cooling, Heating and Fan Schedule
19. (D) 030006-OffMed-Run19 – This test checks if the applicant software models the Standard Design HVAC system in accordance with the requirements of the 2013 Nonresidential ACM. The user model is a medium office building in climate zone 6 with the following characteristics:
    - Core, Mid and Top Bottom Zones are computer rooms with a zone Cooling load greater than 110,000 Btuh-Packaged Single Zone unit and constant volume fan
    - All Perimeter zones- DX Cooling and Hot water Boiler with reheat and variable volume fan
    - Cooling Efficiency- COP=4 (EER - 13.65) for packaged single zone units; COP=3.8 (EER - 12.96) for VAV units serving perimeter zones
    - Heating Efficiency – 80% for VAV unit serving perimeter zones

    The following Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:
    - HVAC System Type
    - Heating and Cooling Type
    - Heating and Cooling Efficiency
    - System Sizing
    - Maximum and minimum supply air temperature
    - SAT Reset Control
    - Economizer Type and limits
    - Fan Power
    - Fan Control Method
    - Cooling and heating capacity adjustment curve
    - Cooling and heating efficiency curve
    - Cooling, Heating and Fan Schedule
    - Terminal heat type and capacity
    - Terminal minimum stop
    - Terminal heat control type
    - Boiler type and Number of boilers

- Boiler Heat loss, boiler minimum unloading ratio
- Hot water supply and return temperature

20. (D) 040006-OffLrg-Run20 – This test checks if the applicant software models the Standard Design HVAC system in accordance with the requirements of the 2013 Nonresidential ACM. The user model is a Large office building in climate zone 6 with the following characteristics:
    - Basement Zone is a computer room with cooling only dedicated packaged DX system.
    - All other zones have a Built-up VAV system.
    - Cooling Efficiency- COP 6.2 for chiller; EER 11, SEER 14 for packaged DX system
    - Heating Efficiency – 82% for boiler; not applicable for packaged DX system

    The following Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:
    - HVAC System Type
    - Heating and Cooling Type
    - Heating and Cooling Efficiency
    - System Sizing
    - Sizing Factor (zone, system)
    - Maximum and minimum supply air temperature
    - SAT Reset Control
    - Economizer Type and limits
    - Fan Power
    - Fan Control Method
    - Cooling, Heating and Fan Schedule
    - Terminal heat type and capacity
    - Boiler type and Number of boilers
    - Boiler Heat loss, boiler minimum unloading ratio
    - Boiler Performance Curve
    - Hot water supply and return temperature
    - Boiler pump type
    - Pump motor power and efficiency
    - Pump part load curve.
    - Chiller Type and Number of chillers
    - Chiller fuel, capacity and efficiency
    - Chiller Minimum Unloading ratio
    - Chiller cooling capacity and adjustment curves
    - Chilled water supply and return air temperature
    - Condenser Type
    - Cooling Tower Fan control type and horse power
    - Cooling Tower Set Point Control
    - Pump Control Type, Motor Power, Efficiency and design flow rate
21. (D) 080006-Whse-Run21 – This test checks if the applicant software models the Standard Design HVAC system in accordance with the requirements of the 2013 Nonresidential ACM.

    The user model is a Warehouse building in climate zone 6 with the following characteristics:
    - Warehouse zones are served by a gas furnace heat only system.
    - Office Zones served by Package Single Zone system with gas furnace heating and DX cooling.
    - Fine Storage HVAC system heating efficiency - 79% AFUE

- Bulk Storage HVAC system heating efficiency – 81% Thermal Efficiency
- Office HVAC system heating efficiency – 79% AFUE
- Office HVAC system cooling efficiency – 11.2 EER

The following Standard Design model inputs shall be verified and reported in the output form provided in Appendix 3C:

- HVAC System Type
- Heating and Cooling Type
- Heating and Cooling Efficiency
- System Sizing
- Maximum and minimum supply air temperature
- Sat Reset Control
- Economizer Type and limits
- Fan Power
- Fan Control Method
- Cooling, Heating and Fan Schedule

22. (D) 07006-HotSml-Run22 – This test checks if the applicant software models the Standard Design HVAC system in accordance with the requirements of the 2013 Nonresidential ACM. The user model is a ten-story Hotel in climate zone 6 with a full-service restaurant, and an assembly area that uses demand control ventilation.
    - Guestrooms are served by a four-pipe fan coil with water-cooled chiller and boiler
    - Building has a water-side economizer

    The following Standard Design inputs shall be verified and reported in the output form provided in Appendix 3C:
    - System Type is four-pipe fan coil for the hotel, and kitchen is served by a dedicated kitchen system with exhaust meeting ACM requirements
    - Assembly area contains demand control ventilation in Standard Design
    - Standard Design building does not contain a water-side economizer
23. (D) 030006-OffMed-Run23 – This test checks the Standard Design building for an existing, altered building that has the roof and windows replaced, as well as a new single-zone system serving an existing conditioned space that has been altered to remove all windows.

    The user model is a medium office in climate zone 6, with the following characteristics:
    - New metal building roof, R-14.58 continuous insulation
    - Fenestration on the top floor South elevation replaced with new windows of the same size (Window Status = New). New Window Properties:
        - Fixed, low-e, double glazed
        - NFRC Rated performance: U=0.40, SHGC=0.33 and VT=0.50.
    - Windows removed from the wall of the top floor, west zone, and replaced with new, in-fill opaque metal frame wall with U-value – 0.068.
    - All other windows on the North, East, West and South facades are existing, unchanged windows. Existing Window Properties:
        - Fixed, Single Pane
        - U=0.55, SHGC=0.56, VT=0.6.
    - A new single-zone HVAC system has been installed to serve the Perimeter_top_ZN_4 Thermal Zone, which has been altered to remove all glazing and the opening replaced with a new in-fill wall

    The following Standard Design Inputs shall be verified and reported in the output form provided in Appendix 3C:
    - Top floor South elevation fenestration properties U, SHGC, and VT.
    - All other facades fenestration properties U, SHGC and VT.
    - HVAC System Type

- New single-zone system serving Perimeter_top_ZN_4 Thermal Zone:
  - Proposed: SEER-18.0/EER 13.1 DX cooling efficiency, 79% AFUE/80.5% furnace thermal efficiency, no economizer.
  - Baseline: Baseline System 3, SEER-13.0, no economizer, 80% furnace thermal efficiency.
- All other zones are served by the existing HVAC systems and are the same in baseline and proposed.
- Heating and Cooling Type
- Heating and Cooling Efficiency
- Baseline construction and u-value for New roof
- Baseline construction and u-value for New west wall

24. (D) 020006-OffSml-Run24– This test checks the Standard Design building for an existing, altered building.
    The user model is a small office in climate zone 6, with the following characteristics:
    - Building WWR = 21%. All fenestration on the south elevation replaced with windows of the same size (Window Status = Altered, no area increase).
    - Altered Window Properties:
      - Fixed, low-e, double glazed
      - NFRC Rated performance: U=0.40, SHGC=0.33 and VT=0.50.
    - Existing Fenestration has the following properties
      - Fixed, Single Pane
      - NFRC Rated Performance U=0.55, SHGC=0.56, VT=0.6.
    - South perimeter zone HVAC systems is replaced with packaged single zone unit having SEER-18.0/EER 13.26 DX cooling efficiency, 78.8% furnace thermal efficiency, no economizer

    The following Standard Design Inputs shall be verified and reported in the output form provided in Appendix 3C:
    - South elevation fenestration properties U, SHGC, and VT.
    - All other facades fenestration properties U, SHGC and VT.
    - HVAC System Type
    - New single-zone system serving Perimeter_ZN_1 Thermal Zone :
      - Proposed: SEER-18.0/EER 13.26 DX cooling efficiency, 78.8% furnace thermal efficiency, no economizer.
      - Baseline: Baseline System 3, SEER-13.0, no economizer, 80% furnace thermal efficiency.
    - All other zones are served by the existing HVAC systems and are the same in baseline and proposed.
    - Heating and Cooling Type
    - Heating and Cooling Efficiency
    - System Sizing
    - Maximum and minimum supply air temperature
    - Fan Control Method
    - Cooling and heating efficiency curve
    - Cooling, Heating and Fan Schedule

25. (D) 020006-OffSml-Run25– This test checks the Standard Design building for an existing, altered building.
    The user model is a small office in climate zone 6, with the following characteristics:

- Building WWR = 42%. All fenestration on the south elevation replaced with windows of the same size (Fenestration Status = Altered). Window Properties:
    - Fixed, low-e, double glazed
    - NFRC Rated performance: U=0.40, SHGC=0.33 and VT=0.50.
- Existing Fenestration has the following properties
    - Fixed, Single Pane
    - NFRC Rated Performance: U=0.55, SHGC=0.56, VT=0.6.
- South perimeter zone HVAC systems is replaced with packaged single zone unit having SEER-18.0/EER 13.26 DX cooling efficiency, 78.8% furnace thermal efficiency, no economizer
-

The following Standard Design Inputs shall be verified and reported in the output form provided in Appendix 3C:

- South elevation fenestration properties U, SHGC, and VT.
- All other facades fenestration properties U, SHGC and VT.
- West Façade and Overall Window Wall Ratio

26. (D) 020006-OffSml-Run26– This test checks the Standard Design building for an existing, altered building.

    The user model is a medium retail building in climate zone 6 with the following characteristics:

    - All fenestration on the south elevation replaced with larger windows (Fenestration Status = New)
    - Added window area increases WWR to 42% and have the following properties:
        - Fixed, low-e, double glazed
        - NFRC Rated performance: U=0.35, SHGC=0.32 and VT=0.53.
    - Existing Fenestration has the following properties
        - Fixed, Single Pane
        - NFRC Rated Performance U=0.55, SHGC=0.56, VT=0.6.
    - South perimeter zone HVAC systems is replaced with packaged single zone unit having SEER-18.0/EER 13.26 DX cooling efficiency, 78.8% furnace thermal efficiency, no economizer

    The following Standard Design Inputs shall be verified and reported in the output form provided in Appendix 3C:

    - South elevation fenestration properties U, SHGC, and VT.
    - All other facades fenestration properties U, SHGC and VT.
    - West Façade and Overall Window Wall Ratio

27. (D) 050006-RetlMed -Run27– This test checks the Standard Design building for an addition, modeled alone.

    - The three south facing zones are modeled as an addition alone.
    - Walls between the addition and the exisiting building (not modeled) area modeled as adiabatic
    - WWR of the south façade is 45%.
    - All fenestration on the south elevation is New. Fenestration Properties:
        - Fixed, low-e, double glazed
        - NFRC Rated performance: U=0.35, SHGC=0.32 and VT=0.53.
    - Lighting Power Density
        - Front Entry space – 1.2 W/ft2
        - Front Retail – 1.6 W/ft2 general lighting and 0.75 W/ft2 Tailored Floor Display Allowance
    - The HVAC system is a dedicated package single zone unit serving the entire addition.

The following Standard Design Inputs shall be verified and reported in the output form provided in Appendix 3C:

- Wall type and construction assembly properties of the adiabatic surfaces
- South elevation fenestration properties U, SHGC, and VT.
- HVAC System Type
- Heating and Cooling Type
- Heating and Cooling Efficiency
- System Sizing
- Maximum and minimum supply air temperature
- Fan Control Method
- Cooling and heating efficiency curve
- Cooling, Heating and Fan Schedule

28. (D) 050006-RetlMed -Run28– This test checks the Standard Design building for an addition modeled with an existing building which includes envelope alterations.

    The user model is a medium retail building in climate zone 6 with the following characteristics:

    - The three south facing zones are modeled as an addition.
    - The two north zones have altered envelope surfaces.
      Core retail west wall is heavy mass altered wall
      Core retail east wall is light mass altered wall
      Core retail roof is wood frame and other altered roof
      Back space west wall is heavy mass new wall
      Back space east wall is metal frame altered wall
      Back space north wall is metal building altered wall
      Back space roof is metal building altered roof
    - The HVAC system is a dedicated package single zone unit serving the addition.

    The following Standard Design Inputs shall be verified:

    - HVAC System Type
    - Heating and Cooling Type
    - Heating and Cooling Efficiency
    - System Sizing
    - Maximum and minimum supply air temperature
    - Fan Control Method
    - Cooling and heating efficiency curve
    - Cooling, Heating and Fan Schedule

29. (D) 030006-OffMed -Run29– This test checks the Standard Design building for an Envelope Only, partial compliance project.

    The user model is a medium office building in climate zone 6 with the following characteristics:

    - Flat, insulation above deck roof with assembly U-value of 0.065, Aged Solar Reflectance of 0.75 and Thermal emittance of 0.78
    - Metal frame wall with assembly U-value of 0.068
    - Mass floor with assembly U-value of 0.039
    - Fixed windows with U-factor of 0.35, SHGC of 0.32 and VT of 0.53
    - No lighting or mechanical system is specified in the user input model (envelope only compliance)

    The following inputs in the Proposed Design and Standard Design model file shall be verified and reported in the output form provided in Appendix 3C:

    - Standard Design roof, wall and floor construction assembly type
    - Standard Design roof, wall and floor overall U-value
    - Standard Design roof, wall and floor construction assembly layer inputs
    - Standard Design roof aged solar reflectance and thermal emittance

- Window U-factor, SHGC and VT
- Lighting Power Density
- HVAC System Type
- Heating and Cooling Type
- Heating and Cooling Efficiency
- System Sizing
- Maximum and minimum supply air temperature
- Fan Control Method
- Cooling and heating efficiency curve
- Cooling, Heating and Fan Schedule

30. (D) 020006-OffMed –Run30– This test checks the Standard Design building for a Lighting and Mechanical partial compliance project
    The user model is a small office building in climate zone 6 with the following characteristics:
    - DX cooling
    - Cooling COP-3.84 (EER 13.1)
    - Gas Furnace Heating
    - Thermal Efficiency – 80%Constant Volume Fan
    - Space Function – Open Office (Greater than 250 square feet in floor area)
    - Lighting:
        - Core Spaces: New Lighting, 0.8 W/ft2 w/ Occupant Sensing Controls
        - South Perimeter Spaces: New Lighting, 0.8 W/ft2, no controls specified
        - Perimeter Spaces: Existing Lighting, 1.2 W/ft2
    - Daylighting:
        - Primary sidelit daylighting controls specified, compliant with mandatory minimums. No Secondary sidelit daylighting controls specified

    The following Standard Design model inputs shall be verified:
    - HVAC System Type
    - Heating and Cooling Type
    - Heating and Cooling Efficiency
    - System Sizing
    - Maximum and minimum supply air temperature
    - Fan Control Method
    - Cooling and heating efficiency curve
    - Cooling, Heating and Fan Schedule
    - Lighting Power Density

3.4.3.1 Results Comparison

The applicant shall perform all tests specified in Section IV and report the outputs in the forms provided in Appendix 3C. Note that the Standard Design for some inputs, such as cooling efficiency and pump power, are dependent upon the autosizing of the HVAC equipment. The ruleset implementation tests do not check that the autosized capacity matches the Reference Method, but rather, that the Standard Design input is properly defined in relation to the autosized capacity.

3.5 Software Sensitivity Tests

This section details the eligibility requirements for an applicant simulation program for use as compliance software under the 2013 Title 24 ACM. A series of **quantitative** tests called the Software Sensitivity Tests shall be performed to measure the change in energy consumption when changing specified input parameters. Applicant software results will be compared against predetermined Reference results to demonstrate that the applicant software is acceptable for use in code compliance. There are a total of 173 tests. All the test cases described here shall be performed and results summarized in the forms contained in Appendix 3B.

3.5.1.1 Overview

The applicant software shall perform a suite of Software Sensitivity Tests to demonstrate that their performance is acceptable for code compliance. The applicant software test results shall be compared against a base case called the Reference test case. The Reference Test case is the corresponding match of a particular test case simulated already on EnergyPlus (v.8.1) engine. The Reference test case results, as determined by the Commission, are tabulated in Appendix 3B.

Test cases specific for Simplified geometry are only for software with 2D inputs for building geometry. Software with 2D geometry approach shall seek certification by submitting the Simplified geometry test cases. In addition, they are also required to produce results for HVAC tests which will be compared against the HAVC reference test results which are common for both simplified and detailed geometry.

The test cases will assess the applicant software's sensitivity to various inputs ranging from envelope thermal conductance to HVAC system performance. Each case tests the impact of the input component on building end use energy and annual TDV. The following six building components will be tested through a series of tests:

- Opaque envelope
- Glazing
- Lighting
- Daylighting
- Receptacle loads
- HVAC System Parameters

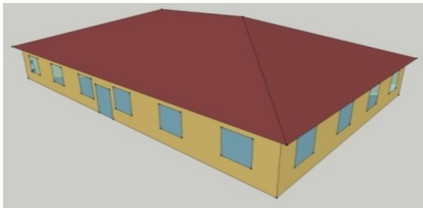
3.5.1.2 Prototype Models

The Software Sensitivity Tests are performed on four Prototype Models which are a subset of the DOE Prototype Building Models developed by PNNL for analysis of ASHRAE Standard 90.1. The Prototype Models are EnergyPlus model input files of the DOE prototype building models, modified to comply with the requirements of Title24-2013. The Prototype Models will be the reference baseline runs for the test cases. The applicant software shall replicate the building models below using the same inputs as the Prototype Models. The models so replicated will be the applicant baseline models for the test cases.

A summary of the Prototype Models is provided in Appendix 3A. Detailed input files of the Reference baseline models are available from the California Energy Commission's Building Energy Efficiency Software Consortium webpage http://bees.archenergy.com/

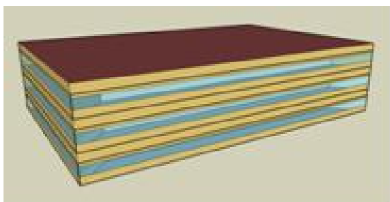
Prototype Models used for Software Sensitivity test cases are:

- Small Office (02000CZ-OffSml):



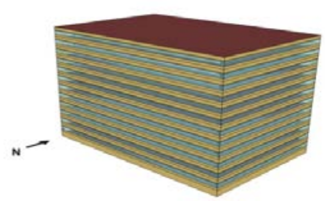
The Small Office model is a single story rectangular shaped building of 5500 square feet area. It has punched windows and a hipped roof with Attic space. There are five zones, each served by packaged single zone air conditioner units. For more details refer Appendix 3A. This ptoptotype is used for the Simple Geometry test cases only.

- Medium Office Building (0300CZ-OffMed):



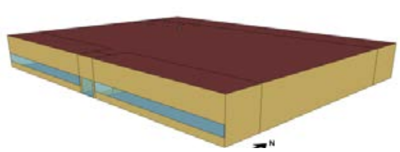
The Medium Office Building model is a three storied rectangular building with an overall area of 53600 square feet. It has a window to wall ratio of 33% with fenestration distributed evenly across all four facades. The zones are served by DX cooling and Gas furnace heating with hot water reheat. For more details refer Appendix 3A. This prototype is used for both Detailed geometry and Simple Geometry test cases.

- Large Office Building (0400CZ-OffLrg):



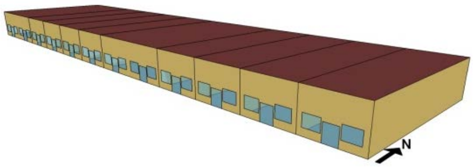
The large office building has twelve floors and a basement floor with glass windows with a window to wall ratio of 40% on the above-grade walls. The total area of the building is 498,600 square feet. The HVAC system type used VAV system. For more details refer Appendix 3A.

- Stand-Alone Retail (0500CZ-RetlMed):



The stand-alone retail is a single story rectangular building measuring 178 ft by 139 ft. The total area is 24695 square feet. Windows are located only on the street facing façade and occupy 25.4% of that façade. The building is divided into five thermal zones which are served by Packaged Single Zone systems as described in Appendix 3A. This prototype is used for both Detailed geometry and Simple Geometry test cases.

- Strip Mall Building Strip Mall-PSZ System (1000CZ-RetlStrp):



The strip mall building area of 22,500 square feet. It has ten zones each with rooftop units. The building has windows in the street facing façade and has an overall window to wall ratio of 10.5%. For more details refer to Appendix 3A.

3.5.1.3 Climate Zones

The Software Sensitivity Test cases use building models for five of the 16 California climate zones. Most tests are performed with two or three climate zones to capture the sensitivity of the input characteristics to extremes in weather conditions. The test cases are performed on climate zones 6, 15 and 16, which represent mild, hot and cold climates respectively. Daylighting tests are performed on climate zone 7, which has a high annual daylighting potential and climate zone 1, representative of the climate with least annual daylighting potential.

Table 2-Climate Zones Tested

Climate Zone	Example City / Weather File
1	Arcata / ARCATA_725945
6	Torrance / TORRANCE_722955
7	San Diego Lindbergh / SAN-DIEGO-LINDBERGH_722900
15	Palm Springs / PALM-SPRINGS-INTL_722868
16	Blue Canyon / BLUE-CANYON_725845

3.5.1.4 Labeling Test Runs

Each test case in the Software Sensitivity test is labeled uniquely to make it easier to keep track of the runs and to facilitate analysis. The following scheme is used:

XXYYYZZ-Prototype-RunDescription
Where XX denotes the Prototype Number
YY denotes Test Run Number
ZZ denote Climate zone

Example:

05 001 15-RetlMed-EnvelopeRoofInsulation — Run Description

Prototype

Climate Zone

Test Run Number

Prototype Number

Example for Simple Geometry Test case

0211015-OffSml-SG-EnvRoofInsulation — Run Description

Prototype

Climate Zone

Test Run Number

Prototype Number

3.5.1.5 Test Criteria

Applicant software vendors shall perform a series of computer runs. Each of these runs shall be a systematic variation of the applicant base case model as described in 3.5.1.7. The applicant test case results will be compared to the reference results to verify that applicant software meets the requirements of the ACM. Simulation results for each test case will be compiled in forms provided in Appendix 3B. Compiled results will include annual site energy consumption for each end-use, overall site energy consumption, total unmet load hours and annual TDV and % variation of annual TDV and total end use site energy.

The annual TDV % variation shall be calculated using the formula:

$TDV_{\%} = (TDV_b - TDV_n)/TDV_b$

Where, $TDV_{\%}$ is the TDV % variation,

TDV_n is the annual TDV for test case number n and

TDV_b is the annual TDV for the base case run.

In order to be accepted, the applicant software should fulfill the passing criteria as determined by the Commission:

For each test case,

The change in energy for the test case must be in the same direction as the Reference Method test case result, and must be equal to the Reference Method test case percentage change in TDV energy, plus or minus 0.5% of baseline TDV energy.

If any of the tests required for the Title 24 compliance feature set fails to meet these criteria, the applicant software will not be accepted for compliance use.

3.5.1.6 Reporting Test Results

For each test case, the TDV energy use of the modeled building is reported (kBtu/ft2), along with the TDV energy use attributed to the major fuel types (electricity, gas), site energy use, and energy end use intensity for the regulated end uses (cooling, heating, lighting, etc.). The following energy totals are reported:

1. Annual TDV EUI (kBtu/ft^2)
2. Annual Site EUI – Electricity (kWh/ft^2)
3. Annual SiteEUI – Natural Gas (therm/ft^2)
4. Annual Total End Use Site Energy EUI – kBtu/ft^2

   Site Energy End Uses
5. Site Energy: Heating (kBtu/ft^2)
6. Site Energy: Cooling (kBtu/ft^2)
7. Site Energy: Interior Lighting (kBtu/ft^2)
8. Site Energy: Interior Equipment (kBtu/ft^2)
9. Site Energy: Fans (kBtu/ft^2) (Airside Fans, does not include tower fans)
10. Site Energy: Pumps (kBtu/ft^2)
11. Site Energy: Towers (kBtu/ft^2)Water heating (kBtu/ft^2)
12. **TDV % Variation** – this field is used for the compliance test
13. Total End Use Site Energy % - percentage change in site energy use
14. Pass/Fail – test fails if it does not meet passing criteria
15. Unmet load hours – these are defined as the zone with the most unmet load hours
    a. Reference Model Occupied Unmet Load Hours
    b. Applicant Model Occupied Unmet Load Hours
    c. Reference Model Number of Zones with excess unmet load hours (>150)
    d. Applicant Model Number of Zones with excess unmet load hours (>150)

AK8

	B	C	Y	Z	AA	AB	AC	AD	AE	AG
1	TEST RESULTS			11		12		13		14
2						Variation from Baseline				
3		Test Case	Btu/sqft)	Water Heating (kBtu/sqft)		TDV % variation		Total End Use Site Energy % Variation		Pass/Fail
4			Applicant Model	Reference Model	Applicant Model	Reference Model	Applicant Model	Reference Model	Applicant Model	
5		**CZ15StandAloneRetailBaseline**		**7.58**						
6	1	01CZ15StandAloneRetail Envelope RoofInsulation		7.57		2.52%		2.37%		Fail
7	2	02CZ15StandAloneRetail Envelope WallInsulation		7.58		0.74%		0.64%		Fail
8	3	03CZ15StandAloneRetail Envelope Heavy		7.57		-5.16%		-3.69%		Fail
9		**CZ16StandAloneRetailBaseline**		**9.73**						
10	4	04CZ16StandAloneRetail Envelope RoofInsulation		9.73		2.01%		2.04%		Fail
11	5	05CZ16StandAloneRetail Envelope WallInsulation		9.73		0.55%		0.79%		Fail
12	6	06CZ16StandAloneRetail Envelope Heavy		9.72		-2.84%		-0.32%		Fail
13		**CZ06StandAloneRetailBaseline**		**8.65**						
14	7	07CZ06StandAloneRetail Envelope RoofInsulation		8.65		0.81%		0.57%		Fail
15	8	08CZ06StandAloneRetail Envelope WallInsulation		8.65		0.49%		0.48%		Fail
16	9	09CZ06StandAloneRetail Envelope Heavy		8.64		-1.25%		0.72%		Fail
17		**CZ15MediumOfficeBaseline**		**2.03**						
18	10	10CZ15MediumOffice Envelope FloorslabInsulation		2.03		-0.77%		-0.53%		Fail
19	11	11CZ15MediumOffice Envelope Infiltration		2.03		-0.26%		-0.29%		Fail
20		**CZ15MediumOfficeBaseline**		**2.03**						

Results / HVAC Results / Sheet3

Ready

Figure 3 – Results Spreadsheet Excerpt from Appendix 3B

The results spreadsheet provides the results of the Reference Method for each test, and provides a column (in orange) for the vendor to report the results from their candidate compliance software.

The variation from baseline section of the spreadsheet shows the percent change in TDV energy use (kBtu/ft2) from the base case for testing. The percentage must be within the passing criteria for the candidate software to pass this test.

Also reported is the number of unmet load hours during occupied hours for the building. An unmet load hour for a specific zone in Title 24 compliance is defined as any hour when the zone has an unmet cooling or heating load. This is typically reported by the software for each zone in the building. For the test case results, two unmet load hour metrics must be reported: the number of unmet load hours for the zone with the greatest number of UMLH, and the number of zones that fail the ACM Reference Manual criteria for acceptable unmet load hours (any zones with greater than 150 hours fail the criteria).

The spreadsheet where the results are documented indicates whether the candidate software passes or fails a test. The result in column AL of the spreadsheet indicates whether or not the candidate software passes the test.

3.5.1.7 Software Sensitivity Test Cases

Test cases assess the energy impact of one or more of the building or system input characteristics on the baseline model. Each test suite consists of a series of unique test cases aimed to test the impact of a specific characteristic on building energy performance. Simulations are grouped according to test criteria and sub-grouped based on the reference model type to allow for direct comparison of results. For each test case, the applicant software will modify the applicant baseline model with specific inputs as described in the Test Case description section.

The test cases are simulated on multiple California weather files to evaluate the sensitivity of the building or system input to extremes in climate. Results of the test case runs and the TDV percent variation over the baseline run shall be compiled and compared against the reference results.

Detailed descriptions of the Standard Design models are provided in Appendix 3A. CBECC input files for all baseline and test case models are available from the California Energy Commission's, Building Energy Efficiency Software Consortium webpage http://bees.archenergy.com. Details on each Test Description can be found in Appendix 3A under the Test Criteria tab.

Table 3 – Baseline Runs for Test Cases

Test Case Summary

0500115-RetlMed-EnvelopeRoofInsulation	**0500015-RetlMed-Baseline**	Decrease overall U value of Roof by 20% compared to baseline case
0500215-RetlMed-EnvelopeWallInsulation		Decrease overall U value of Exterior Wall by 20% compared to baseline case
0500315-RetlMed-EnvelopeHeavy		Change Roof and Wall construction assembly to Wood Framed Roof and Heavy Mass wall. Roof and Wall assembly overall U value of test case= Baseline construction assembly U value
0500416-RetlMed-EnvelopeRoofInsulation	**0500016-RetlMed-Baseline**	Decrease overall U value of Roof by 20% compared to baseline case
0500516-RetlMed-EnvelopeWallInsulation		Decrease overall U value of Exterior Wall by 20% compared to baseline case
0500616-RetlMed-EnvelopeHeavy		Change Roof and Wall construction assembly to Wood Framed Roof and Heavy Mass wall. Roof and Wall assembly overall U value of test case= Baseline construction assembly U value

0500706-RetlMed-EnvelopeRoofInsulation	**0500006-RetlMed-Baseline**	Decrease overall U value of Roof by 20% compared to baseline case
0500806-RetlMed-EnvelopeWallInsulation		Decrease overall U value of Exterior Wall by 20% compared to baseline case
0500906-RetlMed-EnvelopeHeavy		Change Roof and Wall construction assembly to Wood Framed Roof and Heavy Mass wall. Roof and Wall assembly overall U value of test case= Baseline construction assembly U value
0301015-OffMed-FloorSlabInsulation	**0300015-OffMed-Baseline**	Change Floor slab F factor of perimeter zones in the bottom floor to 0.46
0301215-OffMed-GlazingWindowU		Decrease U value of windows by 20% compared to baseline case
0301315-OffMed-GlazingWindowSHGC		Decrease SHGC of windows by 20% compared to baseline case
0301415-OffMed-GlazingWindowUSHGC		Decrease U value & SHGC of windows by 20% compared to baseline case
0301516-OffMed-FloorSlabInsulation	**0300016-OffMed-Baseline**	Change Floor slab F factor of perimeter zones in the bottom floor to 0.46
0301716-OffMed-GlazingWindowU		Decrease U value of windows by 20% compared to baseline case
0301816-OffMed-GlazingWindowSHGC		Decrease SHGC of windows by 20% compared to baseline case
0301916-OffMed-GlazingWindowUSHGC		Decrease U value & SHGC of windows by 20% compared to baseline case
0302006-OffMed-FloorSlabInsulation	**0300006-OffMed-Baseline**	Change Floor slab F factor of perimeter zones in the bottom floor to 0.46
0302206-OffMed-GlazingWindowU		Decrease U value of windows by 20% compared to baseline case
0302306-OffMed-GlazingWindowSHGC		Decrease SHGC of windows by 20% compared to baseline case
0302406-OffMed-GlazingWindowUSHGC		Decrease U value & SHGC of windows by 20% compared to baseline case
0402507-OffLrg-WWR20	**0400007-OffLrg-Baserun**	Reduce window area such that overall window to wall ratio is 20%
0402801-OffLrg-WWR20	**0400001-OffLrg-Baserun**	Reduce window area such that overall window to wall ratio is 20%
0402901-OffLrg-WWR60		Increase window area such that overall window to wall ratio is 60%
0303015-OffMed-LightingLowLPD	**0300015-OffMed-Baseline**	Decrease LPD by 20% compared to baseline case
0303115-OffMed-LightingHighLPD		Increase LPD by 20% compared to baseline case
0303216-OffMed-LightingLowLPD	**0300016-OffMed-Baseline**	Decrease LPD by 20% compared to baseline case
0303316-OffMed-LightingHighLPD		Increase LPD by 20% compared to baseline case
0303406-OffMed-LightingLowLPD	**0300006-OffMed-Baseline**	Decrease LPD by 20% compared to baseline case
0303506-OffMed-LightingHighLPD		Increase LPD by 20% compared to baseline case
0404207-OffLrg-Cont.DimHighVT	**0400007-OffLrg-Baserun**	Increase Visible Transmittance of windows by 20% compared to baseline case
0404307-OffLrg-StepDim		Change daylighting controls in Primary and Secondary daylit areas to Stepped

		dimming with 4 control steps
0404407-OffLrg-StepDimHighVT		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps and increase visible transmittance of windows by 20%
0404507-OffLrg-WWR20Cont.DimHighVT	**0402507-OffLrg-WWR20**	Increase Visible Transmittance of windows by 20% compared to baseline case. Reduce window area such that overall window to wall ratio is 20% Note this test is compared against 042507-OffLrg-WWR20
0404607-OffLrg-WWR20StepDim		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps. Reduce window area such that overall window to wall ratio is 20% Note this test is compared against 0402507-OffLrg-WWR20.
0404707-OffLrg-WWR20StepDimHighVT		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps and increase visible transmittance of windows by 20%. Reduce window area such that overall window to wall ratio is 0.2 Note this test is compared against 0402507-OffLrg-WWR20
0405101-OffLrg-Cont.DimHighVT	**0400001-OffLrg-Baserun**	Increase Visible Transmittance of windows by 20% compared to baseline case
0405201-OffLrg-StepDim		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps
0405301-OffLrg-StepDimHighVT		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps and increase visible transmittance of windows by 20%
0405401-OffLrg-WWR20Cont.DimHighVT	**0402801-OffLrg-WWR20**	Increase Visible Transmittance of windows by 20% compared to baseline case. Reduce window area such that overall window to wall ratio is 20% Note this test is compared against 042801-OffLrgWWR20
0405501-OffLrg-WWR20StepDim		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps. Reduce window area such that overall window to wall ratio is 20% Note this test is compared against 042801-OffLrgWWR20.
0405601-OffLrg-WWR20StepDimHighVT		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps and increase visible transmittance of windows by 20%. Reduce window area such that overall window to wall ratio is 20% Note this test is compared against 042801-OffLrgWWR20.

0405701-OffLrg-WWR60Cont.DimHighVT	**0402901-OffLrg-WWR60**	Increase Visible Transmittance of windows by 20% compared to baseline case. Reduce window area such that overall window to wall ratio is 60% Note this test is compared against 042901-OffLrgWWR60.
0405801-OffLrg-WWR60StepDim		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps. Reduce window area such that overall window to wall ratio is 60% Note this test is compared against 042901-OffLrgWWR60.
0405901-OffLrg-WWR60StepDimHighVT		Change daylighting controls in Primary and Secondary daylit areas to Stepped dimming with 4 control steps and increase visible transmittance of windows by 20%. Reduce window area such that overall window to wall ratio is 60% Note this test is compared against 042901-OffLrgWWR60.
0506007-RetlMed-Daylighting SRRBaseHighVT	**0500007-RetlMed-Baseline**	Increase Visible Transmittance of skylights by 20% compared to baseline case
0506107-RetlMed-Daylighting SRR4.67		Increase skylight area such that overall SRR fraction is 0.0467.
0506207-RetlMed-Daylighting SRR4.67HighVT		Increase skylight area such that overall SRR fraction is 0.0467 and visible transmittance of skylights by 20% compared to baseline case.
0506301-RetlMed-Daylighting SRRBaseHighVT	**0500001-RetlMed-Baseline**	Increase Visible Transmittance of skylights by 20% compared to baseline case
0506401-RetlMed-Daylighting SRR4.67		Increase skylight area such that overall SRR fraction is 0.0467.
0506501-RetlMed-Daylighting SRR4.67HighVT		Increase skylight area such that overall SRR fraction is 0.0467 and visible transmittance of skylights by 20% compared to baseline case.
0306815-OffMed-HVACPVAV Design	**0300015-OffMed-Baseline**	Change static pressure and motor efficiency of all VAV fans. *See details below*
0306915-OffMed-HVACPVAV SATControl		Change supply air temperature reset based on Outside air. *See details below*
0307115-OffMed-HVACPVAV EconomizerType		Change VAV damper control to dual maximum.
0314015-OffMed-FanPwrBox		Change Economizer Type to Fixed Dry bulb with 70 F high limit
0312515-OffMed-Plenum		Impact of heat gain distribution to plenum zones. In this test case, the HVAC return is via plenum zone.
0313415-OffMed-LabExhDOAS	**0300016-OffMed-LabwExh**	Core Mid space of Medium Office building is modelled as a Lab space. This space is served by FPFC with DOAS and has an exhaust system. This case is compared against the OffMed-LabExh run which is similar to the test case but is served by a PVAV system instead of FPFC with DOAS
0307216-OffMed-HVACPVAV Design	**0300016-OffMed-Baseline**	Change static pressure and motor efficiency of all VAV fans. *See details below*

0307316-OffMed-HVACPVAV SATControl		Change supply air temperature reset based on Outside air. *See details below*
0307516-OffMed-HVACPVAV EconomizerType		Change Economizer Type to Fixed Dry bulb with 70 F high limit
0314116-OffMed-FanPwrBox		All zones in Mid floor is served by VAV with series fan powered boxes. All zones in top floor is served by VAV with parallel fan powered boxes.
0312616-OffMed-Plenum		Impact of heat gain distribution to plenum zones. In this test case, the HVAC return is via plenum zone.
0313516-OffMed-LabExhDOAS	**0300016-OffMed-LabwExh**	Core Mid space of Medium Office building is modelled as a Lab space. This space is served by FPFC with DOAS and has an exhaust system. This case is compared against the OffMed-LabExh run which is similar to the test case but is served by a PVAV system instead of FPFC with DOAS
0307606-OffMed-HVACPVAV Design	**0300006-OffMed-Baseline**	Change static pressure and motor efficiency of all VAV fans. *See details below*
0307706-OffMed-HVACPVAV SATControl		Change supply air temperature reset based on Outside air. *See details below*
0307906-OffMed-HVACPVAV EconomizerType		Change Economizer Type to Fixed Dry bulb with 70 F high limit
0314206-OffMed-FanPwrBox		All zones in Mid floor is served by VAV with series fan powered boxes. All zones in top floor is served by VAV with parallel fan powered boxes.
0312706-OffMed-Plenum		Impact of heat gain distribution to plenum zones. In this test case, the HVAC return is via plenum zone.
0313606-OffMed-LabExhDOAS	**0300016-OffMed-LabwExh**	Core Mid space of Medium Office building is modelled as a Lab space. This space is served by FPFC with DOAS and has an exhaust system. This case is compared against the OffMed-LabExh run which is similar to the test case but is served by a PVAV system instead of FPFC with DOAS
0408015-OffLrg-HVACChillerCOP	**0400015-OffLrg-Baserun**	Increase Chiller COP by 18% compared to baseline case
0408416-OffLrg-HVACChillerCOP	**0400016-OffLrg-Baserun**	Increase Chiller COP by 18% compared to baseline case
0408516-OffLrg-HVACChWdeltaT		Change the Chilled water loop design temperature difference to 12F.
0408806-OffLrg-HVACChillerCOP	**0400006-OffLrg-Baserun**	Increase Chiller COP by 18% compared to baseline case
0408906-OffLrg-HVACChWdeltaT		Change the Chilled water loop design temperature difference to 12F.
1009215-RetlStrp-HVACPSZ DXCOP	**1000015-RetlStrp-BaselinePSZ**	Increase COP of DX coil to 3.8
1009315-RetlStrp-HVACPSZ HeatEff		Increase efficiency of the Heating coil to 90%
1009415-RetlStrp-HVACPSZ EconomizerControl		Change Economizer from Integrated as in baseline to NonIntegrated.
1013715-RetlStrp-EvapCooler		Building is served by Water Loop Heat Pump system
1014315-RetlStrp-WLHP		Building is served by Direct and Indirect Evaporative Coolers.

1009516-RetlStrp-HVACPSZ DXCOP	**1000016-RetlStrp-BaselinePSZ**	Increase COP of DX coil to 3.8
1009616-RetlStrp-HVACPSZ HeatEff		Increase efficiency of the Heating coil to 90%
1009716-RetlStrp-HVACPSZ EconomizerControl		Change Economizer from Integrated as in baseline to NonIntegrated.
1013816-RetlStrp-EvapCooler		Building is served by Water Loop Heat Pump system
1014416-RetlStrp-WLHP		Building is served by Direct and Indirect Evaporative Coolers.
1009806-RetlStrp-HVACPSZ DXCOP	**1000006-RetlStrp-BaselinePSZ**	Increase COP of DX coil to 3.8
1009906-RetlStrp-HVACPSZ HeatEff		Increase efficiency of the Heating coil to 90%
1010006-RetlStrp-HVACPSZ EconomizerControl		Change Economizer from Integrated as in baseline to NonIntegrated.
1013906-RetlStrp-EvapCooler		Building is served by Water Loop Heat Pump system
1014506-RetlStrp-WLHP		Building is served by Direct and Indirect Evaporative Coolers.
1010115-RetlStrp-HVACPTAC DXCOP	**1000015-RetlStrp-BaselinePTAC**	Increase COP of DX coil to 3.8
1010515-RetlStrp-FPFC		Building is served by Four Pipe Fan Coil system
1010216-RetlStrp-HVACPTAC DXCOP	**1000016-RetlStrp-BaselinePTAC**	Increase COP of DX coil to 3.8
1010416-RetlStrp-FPFC		Building is served by Four Pipe Fan Coil system
1010306-RetlStrp-HVACPTAC DXCOP	**1000006-RetlStrp-BaselinePTAC**	Increase COP of DX coil to 3.8
1010606-RetlStrp-FPFC		Building is served by Four Pipe Fan Coil system
0512815-RetlMed-SZVAV	**0500015-RetlMed-Baseline**	Building is served by Single zone VAV system
0512916-RetlMed-SZVAV	**0500016-RetlMed-Baseline**	Building is served by Single zone VAV system
0513006-RetlMed-SZVAV	**0500006-RetlMed-Baseline**	Building is served by Single zone VAV system
0413115-OffLrg-CRAC	**0400015-OffLrg-CRAH**	Computer Room in the building is served by CRAC system
0413216-OffLrg-CRAC	**0400016-OffLrg-CRAH**	Computer Room in the building is served by CRAC system
0413306-OffLrg-CRAC	**0400006-OffLrg-CRAH**	Computer Room in the building is served by CRAC system
SIMPLE GEOMETRY TEST CASES		
0211015-OffSml-SG-EnvRoofInsulation	**0200015-OffSml-SG-Baserun**	Decrease overall U value of Roof by 20% compared to baserun case
0211315-OffSml-SG-EnvWallInsulation		Decrease overall U value of Roof by 20% compared to baserun case
0211116-OffSml-SG-EnvRoofInsulation	**0200016-OffSml-SG-Baserun**	Decrease overall U value of Roof by 20% compared to baserun case
0211416-OffSml-SG-EnvWallInsulation		Decrease overall U value of Exterior Wall by 20% compared to baseline case
0211206-OffSml-SG-EnvRoofInsulation	**0200006-OffSml-SG-Baserun**	Decrease overall U value of Exterior Wall by 20% compared to baseline case
0211506-OffSml-SG-EnvWallInsulation		Decrease overall U value of Exterior Wall by 20% compared to baseline case
0311615-OffMed-SG-WWR40	**0300015-OffMed-SG-**	Change WWR from 33% to 40%

0311715-OffMed-SG-WWR20	**Baseline**	Change WWR from 33% to 20%
0312215-OffMed-SG-WinUSHGC		Change WWR from 33% to 40%
0311816-OffMed-SG-WWR40	**0300016-OffMed-SG-Baseline**	Change WWR from 33% to 20%
0311916-OffMed-SG-WWR20		Change WWR from 33% to 40%
0312316-OffMed-SG-WinUSHGC		Change WWR from 33% to 20%
0312006-OffMed-SG-WWR40	**0300006-OffMed-SG-Baseline**	Decrease U value of windows by 20% compared to baseline case
0312106-OffMed-SG-WWR20		Decrease SHGC of windows by 20% compared to baseline case
0312406-OffMed-SG-WinUSHGC		Decrease U value & SHGC of windows by 20% compared to baseline case
0511615-RetlMed-SG-SRR5	**0500015-RetlMed-SG-Baseline**	Change SRR to 5%
0511915-RetlMed-SG-SRR1		Change SRR to 5%
0512215-RetlMed-SG-SkyUSHGC		Change SRR to 5%
0511716-RetlMed-SG-SRR5	**0500016-RetlMed-SG-Baseline**	Change SRR to 1%
0512016-RetlMed-SG-SRR1		Change SRR to 1%
0512316-RetlMed-SG-SkyUSHGC		Change SRR to 1%
0511806-RetlMed-SG-SRR5	**0500006-RetlMed-SG-Baseline**	Decrease U value of skylights by 20% compared to baseline case
0512106-RetlMed-SG-SRR1		Decrease U value of skylights by 20% compared to baseline case
0512406-RetlMed-SG-SkyUSHGC		Decrease U value of skylights by 20% compared to baseline case

3.5.1.8 Results Documentation

The applicant shall perform simulations for all tests specified above. Detailed description of each test case is provided in Appendix 3A and report results in the forms provided in Appendix 3B. Some of the prototype models have some variants of the baseline model. These include 1) Stand Alone Duct Loss baseline- a variant of the Stand-Alone Retail model 2) StripMall-PTAC model- a variant of StripMall- PSZ model and 3) StripMall- Fan Coil model- a variant of StripMall PSZ model. For details please refer Appendix 3A.

Three test cases are presented here as an example: one for building envelope, one for lighting and daylighting, and one for HVAC. The development of the other required test cases follows the same process.

Example Test Case: 0301315-OffMed-GlazingWindowSHGC

For this test case the U-factor and SHGC of all vertical fenestration is decreased by 20%. The prototype used for this test case is a medium office building.

Before the test cases are run, the first step is to generate the prototype models for the four reference buildings, which are required for all of the tests. The four prototype models are defined in the PrototypeModel spreadsheet of Appendix 3A. (Note: while many of the prototype model inputs are based on Title 24 prescriptive requirements, the prototype models do not exactly conform to minimum Title 24 requirements, but rather, are intended to test the sensitivity of the candidate software simulation results to common variations in building inputs

Step 1. Generate prototype models. The first step is to generate the prototype building for the medium office building. The detailed specification of the medium office building is listed in Appendix 3A. A portion of the inputs are shown in the Figure below. The prototypes are defined for the reference models on the Prototype Model tab of Appendix 3A.

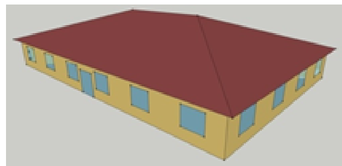
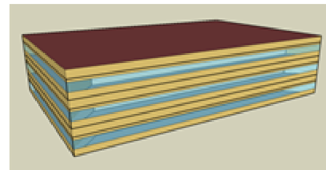
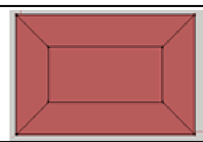
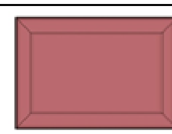
Prototype Description	Small Office Building	Medium Office Building
Vintage	New Construction	New Construction
Location	CZ-6/15/16	CZ-3/6/15/16
Fuel Type	gas, electricity	gas, electricity
Total Floor Area (sq feet)	5500 (90.8 ft x 60.5ft)	53600 (163.8 ft x 109.2 ft)
Building shape		
Aspect Ratio	1.5	1.5
Number of Floors	1	3
Window Fraction (Window-to-Wall Ratio)	24.4% for South and 19.8% for the other three orientations (Window Dimensions: 6.0 ft x 5.0 ft punch windows for all façades)	33% (Window Dimensions: 163.8 ft x 4.29 ft on the long side of facade 109.2 ft x 4.29 ft on the short side of the façade)
Window Locations	evenly distributed along four façades	evenly distributed along four façades
Shading Geometry	none	none
Azimuth	non-directional	non-directional
Thermal Zoning	Perimeter zone depth: 16.4 ft. Four perimeter zones, one core zone and an attic zone. Percentages of floor area: Perimeter 70%, Core 30%	Perimeter zone depth: 15 ft. Each floor has four perimeter zones and one core zone. Percentages of floor area: Perimeter 40%, Core 60%
		
Floor to floor height (feet)	10	13

Figure 4 – Prototype Model Definition from Appendix 3A

The prototype model definition in the spreadsheet contains links to other input definitions:

Row 19, 26, 45: Links to layer-by-layer exterior construction assembly definitions in the *ConstructionAssembly* tab

Row 52: links to layer-by-layer interior construction assembly definitions in the *ConstructionAssembly* tab

Step 2. Define base case and variation for test run.

The base case is defined as the starting point for each test. In many tests, the base case will be one of the prototype models. However, in some cases, a variation of the prototype may serve as the base case for the test.

For this test, the base case is found by looking at the Test Criteria tab of Appendix 3A or ***Table 3 – Baseline Runs for Test Cases***.

Y4 | *fx* Decrease U value & SHGC of windows by 20% compared to baseline case

	A	U	V	W	X
2	**Test Run Name**	**20CZ06MediumOffice Envelope FloorslabInsulation**	**21CZ06MediumOffice Envelope Infiltration**	**22CZ06MediumOffice Glazing WindowU**	**23CZ06MediumOffice Glazing WindowSHGC**
3	**Baseline**	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice
4	**Test Description**	Change Floor slab F factor to 0.45	Increase Exterior Wall Infiltration by 10% compared to baseline case	Decrease U value of windows by 20% compared to baseline case	Decrease SHGC of windows by 20% compared to baseline case
5	Location	CZ06	CZ06	CZ06	CZ06

Figure 5 – Base Case Definition from Appendix 3A

For this test, the Baseline field in row 3 of the *TestCriteria* tab shows that the baseline is *CZ06MediumOffice*, the medium office prototype in climate zone 6.

This same TestCriteria tab shows the input(s) to be verified, which are highlighted in purple. For this test, the solar heat gain coefficient of all vertical fenestration is reduced by 20%, from 0.25 to 0.20.

A	U	V	W	X
Test Run Name	**20CZ06MediumOffice Envelope FloorslabInsulation**	**21CZ06MediumOffice Envelope Infiltration**	**22CZ06MediumOffice Glazing WindowU**	**23CZ06MediumOffice Glazing WindowSHGC**
Baseline	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice	CZ06MediumOffice
Test Description	Change Floor slab F factor to 0.45	Increase Exterior Wall Infiltration by 10% compared to baseline case	Decrease U value of windows by 20% compared to baseline case	Decrease SHGC of windows by 20% compared to baseline case
Location	CZ06	CZ06	CZ06	CZ06
Dimensions				
Tilts and orientations		Refer MediumOffice		
Window				
Dimensions				
Glass-Type and frame				
U-factor (Btu / h * ft^2 * °F)			0.29	
SHGC				0.2
Visible transmittance				
Operable area				

Figure 6 – Input Parameter Variation for Medium Office from Appendix 3A

Step 3. Run the base case model and generate test results.

Once the base case model is developed, the simulation is run and the results are recorded onto the spreadsheet of test cases, Appendix 3B.

The candidate software shall report electricity use by end use, gas use by end use, TDV energy and unmet load hours. For purposes of compliance, unmet load hours are defined at the zone level, and the zone with the greatest number of unmet load hours must pass the criteria specified in the sizing procedure.

For the Reference Tests, the HVAC system's capacities and flow rates can be found in Appendix 3A under the Sizing Values tab.

Step 4. Run the test case model (with the reduced solar heat gain coefficient) and report the results.

The model is re-run and the energy results and outputs are reported. The percentage change in energy use is reported.

Step 5. Report the change in regulated TDV energy use from the base case as a percentage change.

The reported percentage change in energy use from the candidate compliance software must fall within the passing criteria for the Reference Method.

4. Content and Format of Standard Reports

4.1 Overview

THE NUMBER, STRUCTURE AND CONTENT OF THE REPORTS WILL BE DETERMINED.

This chapter provides a summary of the requisite content and format of the Title 24 standard reports. These reports standardize the way energy modeling output data is delivered to the California Energy Commission, either in electronic or printed format. Electronically formatted output reports may be uploaded to the CEC registry according to procedures TBD.

4.1.1 Content

Content TBD.

4.1.2 Format

Format TBD.

4.2 Electronic Format: XML

A possible option is for the compliance software to generate reports in an electronic format, so that they may be readily uploaded to the commission or other appropriate AHJ. This feature has not yet been included in the scope of the compliance reports. The details of the compliance forms and reports need to be specified.

4.3 Hard Copy Format: PDF

The compliance software will produce required compliance reports for new construction or alterations projects. The following section provides examples of the automatically generated standard reports. These examples are representative of a typical report output; however, they are not exhaustive.

Contents TBD.

5. Building Descriptors Reference

5.1 Overview

This chapter specifies for each building descriptor the rules that apply to the proposed design and to the standard design.

5.1.1 Definition of Building Descriptors

Building descriptors provide information about the proposed design and the standard design. In this chapter, the building descriptors are discussed in the generic terms of engineering drawings and specifications. By using generic building descriptors, this manual avoids bias toward one particular energy simulation engine. The building descriptors in this chapter are compatible with commonly used simulation software.

Each energy simulation program has its own way of accepting building information. EnergyPlus, for instance, uses a comma delimited data file called an IDF file. DOE-2 uses BDL (building design language) to accept information. It is the responsibility of the compliance software to translate the generic terms used in this chapter into the “native language” of the simulation program. Figure 7 illustrates the flow of information.

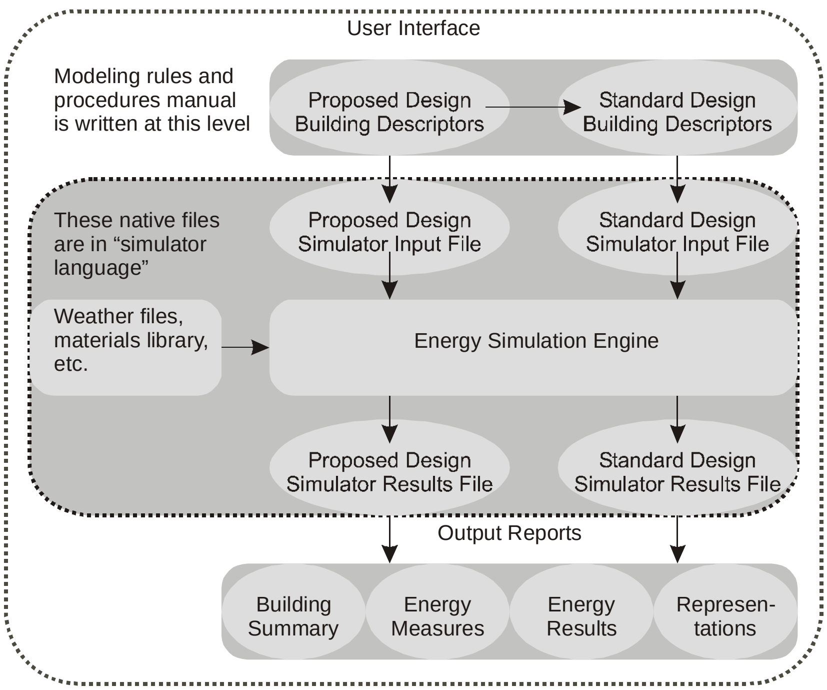


Figure 7 – Information Flow

5.1.2 HVAC System Map

The HVAC system in the standard design depends on the primary building activity, the size of the building and the number of floors. Details about these systems are provided in subsequent sections.

Many of the building descriptors have a one-to-one relationship between the proposed design and the standard design, for example, every wall in the proposed design has a corresponding wall in the standard design. However, for HVAC systems, this one-to-one relationship generally does not hold. The HVAC system serving the proposed design and the standard design may be completely different, each with different components, etc.

HVAC system in the *standard design* shall be selected from Table 4 – HVAC System Map and be based on building type, number of floors, conditioned floor area, and heating source. Additionally, the selected system shall conform to the descriptions in Table 5 – System Descriptions.

For systems 1, 2, 3, 7, 10 and 11, each thermal zone shall be modeled with its own HVAC system. For systems 5, 6, and 9, each floor shall be modeled with a separate HVAC system. Floors with identical thermal zones and occupancies can be grouped for modeling purposes. The standard design heating source is natural gas.

Table 6 – HVAC System Map

Building Type	Standard Design
Residential or hotel/motel guestrooms in a building with 3 or fewer floors	System 1 - PTAC
Residential or Hotel/motel Guestrooms in a building with 4 or more floors	System 2 - FPFC
Warehouse and light manufacturing space types (per the Appendix 5.4A Schedule column) that do not include cooling in the proposed design	System 9 - HEATVENT
Covered Process	*See* Table 8 –System Map for Covered Processes
All other space types	*See* Table 7 – Non-Residential Spaces (not including covered processes)

Table 7 – Non-Residential Spaces (not including covered processes)

Building Area	Floors	Standard Design	Description
≤ 10,000 ft^2	1 floor	PSZ	Packaged Single Zone
	>1 floor	PVAV	Packaged VAV Unit
10,000 ft2 – 150,000 ft2	Any	PVAV	Packaged VAV Unit
>150,000 ft2	1 floor	SZVAV	Single-zone VAV Unit
	>1 floor	VAVS	Built-up VAV Unit

Table 8 –System Map for Covered Processes

Building Type or Space Type	Floors	Baseline System
Total computer room design cooling load is over 3,000,000 Btu/h Note: if the user chooses computer room for the space type and enters a receptacle load less than 20 W/ft^2 then the proposed and baseline shall use a receptacle load of 20 W/ft^2.	Any	System 10 – CRAH Unit
Computer rooms that do not meet the conditions for System 10, CRAH	Any	System 11 – CRAC Unit
Laboratory Space	Any	System 12 – LAB
Restaurant Kitchen	Any	System 13 – KITCH

Table 9 – System Descriptions

System Type	Description	Detail
System 1 – PTAC	Packaged Terminal Air Conditioner	Ductless single-zone DX unit with hot water natural gas boiler
System 2 – FPFC	Four-Pipe Fan Coil	Central plant with terminal units with hot water and chilled water coils, with separate ventilation source
System 3 – PSZ	Packaged Single Zone	Single-zone constant volume DX unit with gas heating
System 4 – RESERVED		
System 5 – PVAV	Packaged VAV Unit	VAV reheat system; packaged variable volume DX unit with gas heating and with hot water reheat terminal units
System 6 – VAVS	Built-up VAV Unit	Variable volume system with chilled water and hot water coils, water-cooled chiller, tower and central boiler
System 7 – SZVAV	Packaged Single-Zone VAV Unit	Single-zone variable volume DX unit with variable-speed drive and gas heating
System 8 – RESERVED		
System 9 – HEATVENT	Heating and Ventilation Only	Gas heating and ventilation
System 10 – CRAH	Computer Room Air Handler	Built-up variable volume unit with chilled water, no heating
System 11 – CRAC	Computer Room Air Conditioner	Packaged variable volume DX unit with no heating
System 12 – LAB	Laboratory HVAC System	For floor area < 50,000 ft2:packaged variable volume system with 100% OA and minimum ventilation rate of 6 ACH For Floor Area>= 50,000 ft2, built-up VAV (VAVS) with water-cooled chiller and central boiler
System 13 – KITCH	Kitchen HVAC System	Dedicated makeup air unit (MAU) – CHW if building is VAVS, DX otherwise. Dedicated exhaust fan.

Separate occupancies in mixed use buildings are served by separate standard design systems. Examples include residential spaces located over retail and other similar conditions (See ASHRAE 90.1 G3.1.1, Exception a). For example a 100,000 ft^2 building that had retail and restaurant on floor 1, offices on floors 2-4, a 20 ton computer room on each office floor, and residential on floors 5-7 would have the following systems in the standard design:

- A KITCH serving the restaurant
- A VAVS serving all retail and office spaces
- Separate CRAC systems serving each computer room
- Separate FPFC systems serving each residential space

The baseline building shall have only one central chilled or hot water plant, so if there are multiple systems that incorporate a plant (e.g. CRAH and VAVS) then a single plant shall serve all plant loads.

For additions and alterations projects, the standard design building shall follow the same rules as the HVAC system map above, except that the building that will follow the logic of the system map rules may be the ***modeled*** building (the addition or alteration alone, or the addition or alteration and a portion of the existing building), or the ***entire*** building (the entire existing building, plus an addition, if present).

The decision on the existing building basis for applying the system map rules is:

General System Modification

The following rules apply to any building that has both heating and cooling systems.

1. Plant: if the change in plant cooling capacity exceeds 50% of the existing **total cooling capacity of all cooling systems**, the system map is based on the entire building characteristics (see Section 5.2.2).

2. Airside System: if the change in cooling capacity of the airside system (air handling units, DX packaged units, for example) of all cooling sources other than chilled water exceeds 50% of the existing rated cooling capacity for the building, then the HVAC system map is based on the entire building characteristics. Also, if the combined net cooling capacity of all altered airside systems exceeds 90% of the building cooling capacity, then the HVAC system map is based on the entire building characteristics.

3. Zone Level: if the change in the cooling capacity of the zonal systems (PTAC units, FPFC units, for example), exceeds 50% of the rated total cooling capacity of all zonal systems in the existing building, then the HVAC system map is based on the entire existing building characteristics. Also, if the combined net cooling capacity of all altered zonal systems exceeds 90% of the building cooling capacity, then the HVAC system map is based on the entire building characteristics. This applies only to systems who

4. If none of these three conditions apply above, then the HVAC system map is based on the building characteristics of the *modeled* building for additions and alterations compliance, which may be just a portion of the entire building.

Since some additions and alterations projects will trigger the HVAC system map for the standard design, the user must enter a minimum set of building characteristics for the entire building (existing plus any addition): existing building floor area and number of stories must be entered.

Heating Only System Modification

The following rules apply to any building that only has heating only systems.

1. Plant: if the change in plant heating capacity exceeds 50% of the existing total space heating capacity of all heating systems, the system map is based on the entire building characteristics.

2. Airside System: if the change in heating capacity of the airside system (unitary DX equipment, heat pumps, for example) of all heating sources other than heating hot water exceeds 50% of the existing rated cooling capacity for the building, then the HVAC system map is based on the entire building

characteristics. Also, if the combined net heating capacity of all altered airside systems exceeds 90% of the building heating capacity, then the HVAC system map is based on the entire building characteristics.

3. Zone Level: if the change in the heating capacity of the zonal systems (PTAC units, for example), exceeds 50% of the rated total heating capacity of all zonal systems in the existing building, then the HVAC system map is based on the entire existing building characteristics. Also, if the combined net cooling capacity of all altered zonal systems exceeds 90% of the building cooling capacity, then the HVAC system map is based on the entire building characteristics.

4. If none of these three conditions apply above, then the HVAC system map is based on the building characteristics of the *modeled* building for additions and alterations compliance, which may be just a portion of the entire building.

Since some additions and alterations projects will trigger the HVAC system map for the standard design, the user must enter a minimum set of building characteristics for the entire building (existing plus any addition): existing building floor area and number of stories must be entered.

5.1.3 Organization of Information

Building descriptors are grouped under objects or building components. A wall or exterior surface (an object) would have multiple building descriptors dealing with its geometry, thermal performance, etc. Each building descriptor contains the following pieces of information.

Building Descriptor Title	
Applicability	Information on when the building descriptor applies to the proposed design
Definition	A definition for the building descriptor
Units	The units that are used to prescribe the building descriptor. A “List” indicates that a fixed set of choices applies and the user shall only be allowed to enter one of the values in the list.
Input Restrictions	Any restrictions on information that may be entered for the proposed design
Standard Design	This defines the value for the “Standard Design” or baseline building is applied for this building descriptor. A value of “Same as proposed” indicates that the building descriptor is neutral; that is, the value is set to match the proposed design value. In many cases, the value may be fixed, or may be determined from a table lookup. In some cases the input may not be applicable: for example, heat recovery effectiveness is not applicable because the standard design (baseline building) does not have heat recovery.

5.1.4 Special Requirements for Additions and Alterations Projects

Compliance projects containing additions and/or alterations require that the user designate each building component (envelope construction assemblies and fenestration, lighting, HVAC and water heating) as either: new, alteration or addition. Many of the building descriptors in Chapter 5 of this ACM Reference Manual do not have explicit definitions for the standard design when the project is an addition and/or alterations project. For these terms, the standard design rules for existing, altered components follow the same rule as the standard design rule for new construction.

For example, the receptacle loads are prescribed for both the proposed design building and standard design building for a new construction compliance project. For additions or alterations to an existing building, since the rules are not explicitly defined in the building descriptor in section 5.3.3, the same rules apply to the proposed design and standard design for the additions or alterations compliance project.

Building descriptors that are prescribed for the proposed and standard design models for new construction projects are also prescribed for the proposed and standard design models for additions and alterations projects.

For additions and alterations projects, there are three different modeling approaches that can be taken when modeling the existing building:

(1) **Model the addition or altered portion alone.** For this option, the addition or alteration is modeled as a standalone building, and the boundary or interface between the addition and/or alteration and the preexisting building is modeled as an adiabatic partition (an adiabatic wall, ceiling, roof or floor).

(2) **Model the entire existing building and any additions and alterations**. For this option, the existing, unaltered components of the building would be modeled “as designed” (as specified by the user), with the standard design component components modeled the same as the proposed design.

(3) **Model part of the existing building and any additions and alterations**. For this option, all components of the existing, unaltered building (HVAC, lighting, envelope, spaces) would have to be distinguished from the components that are added and altered. The existing building components would be modeled “as designed” (as specified by the user), with the standard design components modeled the same as the proposed design. Added or altered building components would follow the rules for additions and alterations.

When either option 1 or option 3 is used, the adiabatic partitions shall not be considered as part of gross exterior wall area or gross exterior roof area for window wall ratio (WWR) and skylight roof ratio (SRR) calculations.

5.2 Project Data

5.2.1 General Information

Project Name	
Applicability	All projects
Definition	Name used for the project, if one is applicable
Units	Up to 50 alphanumeric characters
Input Restrictions	Input is optional for the proposed design.
Standard Design	Not applicable

Project Address	
Applicability	All projects
Definition	Street address, city, state, and zip code
Units	Up to 50 alphanumeric characters on each of two lines
Input Restrictions	Input is mandatory for the proposed design.
Standard Design	Not applicable

Project Owner

Applicability	All projects
Definition	Owner(s) of the project or individual or organization for whom the building permit is sought. Information should include name, title, organization, email, and phone number.
Units	Up to 50 alphanumeric characters
Input Restrictions	Input is optional for the proposed design.
Standard Design	Not applicable

Architect

Applicability	All projects
Definition	Architect responsible for the building design. Information should include name, title, organization, email, and phone number.
Units	Up to 50 alphanumeric characters
Input Restrictions	Input is mandatory for the proposed design.
Standard Design	Not applicable

HVAC Engineer

Applicability	All projects
Definition	HVAC Engineer responsible for the building design. Information should include name, title, organization, email, and phone number.
Units	Up to 50 alphanumeric characters
Input Restrictions	Input is mandatory for the proposed design. Information should include name, title, organization, email, and phone number.
Standard Design	Not applicable

Lighting Engineer/Designer

Applicability	All projects
Definition	Lighting Engineer/Designer responsible for the building design. Information should include name, title, organization, email, and phone number.
Units	Up to 50 alphanumeric characters
Input Restrictions	Input is mandatory for the proposed design.
Standard Design	Not applicable

Energy Modeler

Applicability	All projects
Definition	Individual responsible for performing the compliance analysis. Information should include name, title, organization, email, and phone number.
Units	Up to 50 alphanumeric characters
Input Restrictions	Input is mandatory for the proposed design.
Standard Design	Not applicable

Date

Applicability	All projects
Definition	Date of completion of the compliance analysis or the date of its most-recent revision
Units	Date format
Input Restrictions	Input is mandatory for the proposed design.
Standard Design	Not applicable

Compliance Type

Applicability	All projects
Definition	Type of compliance project (new construction, partial compliance or additions and alterations).
Units	List: New Complete – new construction project New Envelope Only – new construction, partial compliance with envelope. New Envelope and Lighting Only – new construction, partial compliance with envelope and lighting. New Envelope and Partial Lighting Only – new construction, partial compliance with envelope and lighting compliance ***for some spaces***. New Mechanical Only – new construction, partial compliance with mechanical. This is the complement of a partial compliance wiith Envelope and Lighting, which should have already been performed. New Mechanical and Lighting Only – new construction, partial compliance with mechanical and lighting only. The building should have already passed an Envelope Only partial compliance. New Mechanical and Partial Lighting Only – new construction, partial compliance with envelope. Addition – addition project (new conditioned floor area and volume) Alteration – alteration project Addition And Alteration – project with both additions and alterations
Input Restrictions	As Designed
Standard Design	Same as Proposed

5.2.2 Existing Building Classification

Existing Building Number of Stories

Applicability	Additions and alterations
Definition	The total number of stories of the building. For information and reporting purposes only.
Units	integer

Input Restrictions	As designed
Standard Design	Not applicable
Standard Design, Existing Buildings	Not applicable

Existing Building Floor Area

Applicability	Additions and alterations
Definition	The total floor area of an existing building, including any additions, if present. For information and reporting purposes only.
Units	ft^2
Input Restrictions	As designed
Standard Design	Not applicable
Standard Design, Existing Buildings	Not applicable

5.2.3 Partial Compliance Model Input Classification

Earlier sections of this reference manual have described the available partial compliance scenarios. The compliance software that supports these scenarios must define the inputs for both the proposed design and the standard design for unpermitted portions of the building.

1) Envelope Only – the user specifies the building envelope and all spaces, space types and thermal zones in the building. The standard design rules are applied to the envelope components. For all lighting and HVAC inputs, the proposed design values are prescribed and follow the rules for the standard design, including modeling the same HVAC systems determined using the new construction HVAC system map in Section 5.1.2..
2) Envelope and Lighting Only – the user specifies the building envelope, spaces, space types, thermal zones and all lighting, and any daylighting, where present. For all HVAC inputs, the proposed design values are prescribed and follow the rules for the standard design, including modeling the same HVAC systems determined using the new construction HVAC system map in Section 5.1.2.
3) Envelope and Partial Lighting Only – this compliance option is used for projects where the building envelope is defined, and where the lighting in some of the spaces is defined. The user specifies the building envelope, all spaces, space types, thermal zones and lighting for spaces with lighting systems defined, and any daylighting, where present. For all HVAC inputs, the proposed design values are prescribed and follow the rules for the standard design, including modeling the same HVAC systems determined using the new construction HVAC system map in Section 5.1.2.
4) Mechanical Only – this compliance option assumes that the building has already been permitted for envelope and lighting. The envelope and lighting systems for both the proposed design and the standard design are modeled as designed. (For example, if the building vertical fenestration area exceeds prescriptive WWR limits, the limits are NOT applied to the standard design. Instead, the actual vertical fenestration area is used.) The mechanical systems of the proposed model are described as-designed, and the new construction rules and system map are applied to the HVAC system of the standard design.
5) Mechanical and Lighting Only – this compliance option assumes that the building has already been permitted for envelope compliance. All spaces and space types must be defined by the user, and all envelope components for the proposed design are "as designed" (must be defined by the user). The standard design lighting and HVAC components are set to match the standard design.
6) Mechanical and Partial Lighting Compliance – this compliance option assumes that the building has already been permitted for Envelope and Partial Lighting compliance (option 3 above). The envelope components, spaces and space types and permitted lighting spaces are entered as designed for the proposed design, and for these components, the standard design is set to be the same as the proposed. For the other components as part of the permit application, the mechanical systems and new lighting systems are entered by the user for the proposed design as designed, and the standard design components for the mechanical (HVAC) system and new lighting systems are defined by the new construction standard design rules.

Building descriptors whose inputs for both the proposed design and standard design are restricted to prescribed values (equipment performance curves, for example) follow the same rules for prescribed values for any of the partial compliance projects listed above.

5.2.4 Building Model Classification

The structure of this manual supports multiple purposes and multiple baselines. For example, a baseline used for Title 24 compliance might be separate from a baseline used for green building ratings or beyond code programs. A building descriptor "Purpose" could be used to identify different baselines, but is not within the current scope of this manual.

Space Classification Type

Applicability	All projects
Definition	One of two available classification methods for identifying the function of the building or the functions of spaces within the building, which in turn determine energy-related requirements for the standard design. Appendix 5.4A lists the building classifications that are available under the complete building method and area category method. The Complete Building method uses the same space definitions for all spaces within a building, and the building type must match one of the types in the list in the Appendix. The Area Category method uses a separate space classification for each space in the building according to its function.
Units	List: Complete Building, Area Category
Input Restrictions	For multi-use buildings, the building may be divided and a different building classification may be assigned to each part. Either the complete building method or the area category method must be used, but the two classification methods may not be mixed within a single compliance run.
Standard Design	Same as proposed

Building Classification

Applicability	When the complete building method is used instead of the area category method of classifying activity in the building
Definition	The building type or principal activity. One of two available classification methods for identifying the function of the building or the functions of spaces within the building, which in turn determine energy-related requirements for the standard design. Appendix 5.4A lists the building classifications that are available under the complete building method.
Units	List: Choose a building activity from Appendix 5.4A
Input Restrictions	For multi-use buildings, the building may be divided and a different building classification may be assigned to each part. Either the complete building method or the area category method must be used, but the two classification methods may not be mixed within a single compliance run.
Standard Design	Same as proposed

5.2.5 Geographic and Climate Data

The following data needs to be specified or derived in some manner. Software developers may use any acceptable method to determine the data. For California, city, state and county are required to determine climate data from the available data in Reference Appendix JA2

Zip Code	
Applicability	All projects
Definition	California postal designation
Units	List
Input Restrictions	None
Standard Design	Not applicable

Latitude	
Applicability	All projects
Definition	The latitude of the project site
Units	Degrees (°)
Input Restrictions	None
Standard Design	Latitude of representative city from Reference Appendix JA2

Longitude	
Applicability	All projects
Definition	The longitude of the project site
Units	Degrees (°)
Input Restrictions	None
Standard Design	Longitude of representative city from Reference Appendix JA2

Elevation	
Applicability	All projects
Definition	The height of the building site above sea level
Units	Feet (ft)
Input Restrictions	None
Standard Design	Elevation of representative city from Reference Appendix JA2

California Climate Zone	
Applicability	All projects
Definition	One of the 16 California climate zones
Units	List
Input Restrictions	None
Standard Design	Same as proposed

Daylight Savings Time Observed	
Applicability	All projects
Definition	An indication that daylight savings time is observed. The schedules of operation are

	shifted by an hour twice a year and this affects solar gains, temperature and other factors.
Units	Boolean (True/False)
Input Restrictions	True
Standard Design	True

County

Applicability	All projects
Definition	The county where the project is located
Units	List
Input Restrictions	None
Standard Design	County of representative city from Reference Appendix JA2

City

Applicability	All projects
Definition	The city where the project is located
Units	List
Input Restrictions	None
Standard Design	Representative city from Reference Appendix JA2

Design Day Data

Applicability	All projects
Definition	A data structure indicating design day information used for the sizing of the proposed system. Note that this information may not necessarily match the information used in the annual compliance simulation.
Units	Data Structure: contains the following:
	Design DB (0.5%), Mean Coincident Wet-Bulb, Daily Range, Day of Year
Input Restrictions	The design day information is taken from one of the 86 pre-defined California weather files, for the location within the same climate zone that is closest to the proposed building's location. (This is not input by the user.)
Standard Design	Not applicable

Weather File

Applicability	All projects
Definition	The hourly (i.e., 8,760 hour per year) weather data to be used in performing the building energy simulations. Weather data must include outside dry-bulb temperature, outside wet-bulb temperature, atmospheric pressure, wind speed, wind direction, cloud amount, cloud type (or total horizontal solar and total direct normal solar), clearness number, ground temperature, humidity ratio, density of air, and specific enthalpy.
Units	Data file
Input Restrictions	The weather file selected shall be in the same climate zone as the proposed design. If

multiple weather files exist for one climate zone then the weather file closest in distance to the proposed design and in the same climate zone shall be used.

Standard Design Weather data shall be the same for both the proposed design and standard design.

Ground Reflectance

Applicability All projects

Definition Ground reflectance affects daylighting calculations and solar gain. The reflectance can be specified as a constant for the entire period of the energy simulation or it may be scheduled, which can account for snow cover in the winter.

Units Data structure: schedule, fraction

Input Restrictions Prescribed. The weather file determines the ground reflectance. The ground reflectance shall be set to 0.2 when the snow depth is 0 or undefined, and set to 0.6 when the snow depth is greater than 0.

Standard Design Same as proposed

Local Terrain

Applicability All projects

Definition An indication of how the local terrain shields the building from the prevailing wind. Estimates of this effect are provided in the ASHRAE Handbook of Fundamentals.

Units List: the list shall contain only the following choices:

Description	Exponent (α)	Boundary layer thickness, δ (m)
Flat, open country	0.14	270
Rough, wooded country, Suburbs	0.22	370
Towns and cities	0.33	460
Ocean	0.10	210
Urban, industrial, forest	0.22	370

The exponent and boundary layer are used in the following equation to adjust the local wind speed:

$$V_z = V_{met}\left(\frac{\delta_{met}}{z_{met}}\right)^{\alpha_{met}}\left(\frac{z}{\delta}\right)^{\alpha}$$

Where:

z = altitude, height above ground (m)

V_z = wind speed at altitude z *(m/s)*

α = wind speed profile exponent at the site

δ = wind speed profile boundary layer thickness at the site (m)

z_{met} = height above ground of the wind speed sensor at the meteorological station (m)

V_{met} = wind speed measured at the meteorological station (m/s)

α_{met} = wind speed profile exponent at the meteorological station

δ_{met} = wind speed profile boundary layer thickness at the meteorological station. (m)

The wind speed profile coefficients α, δ, α_{met}, and δ_{met}, are variables that depend on the roughness characteristics of the surrounding terrain. Typical values for α and δ are shown in the table above.

Input Restrictions	Weather data should be representative of the long term conditions at the site
Standard Design	The standard design terrain should be equal to the proposed design

5.2.6 Site Characteristics

Shading of Building Site	
Applicability	All projects
Definition	Shading of building fenestration, roofs, or walls by other structures, surrounding terrain, vegetation, and the building itself
Units	Data structure
Input Restrictions	The default and fixed value is for the site to be unshaded. External shading from other buildings or other objects is not modeled for Title 24 compliance in the ACM.
Standard Design	The proposed design and standard design are modeled with identical assumptions regarding shading of the building site.

Site Fuel Source	
Applicability	All projects
Definition	The fuel source that is available at the site for water heating, space heating or other fuel purposes. For most buildings connected to a utility service, this will be natural gas.
Units	List
Input Restrictions	The following choices are available: Natural Gas Propane
Standard Design	Natural Gas

5.2.7 Calendar

Year for Analysis	
Applicability	All projects
Definition	The calendar year to be used for the annual energy simulations. This input determines

	the correspondence between days of the week and the days on which weather events on the weather tape occur and has no other impact.
Units	List: choose a year (other than a leap year).
Input Restrictions	Use year 1991.
Standard Design	Same calendar year as the proposed design

Schedule of Holidays

Applicability	All projects
Definition	A list of dates on which holidays are observed and on which holiday schedules are used in the simulations
Units	Data structure
Input Restrictions	The following ten holidays represent the prescribed set. When a holiday falls on a Saturday, the holiday is observed on the Friday proceeding the Saturday. If the holiday falls on a Sunday, the holiday is observed on the following Monday.

New Year's Day	January 1
Martin Luther King Day	Third Monday in January
Presidents Day	Third Monday in February
Memorial Day	Last Monday in May
Independence Day	July 4
Labor Day	First Monday in September
Columbus Day	Second Monday in October
Veterans Day	November 11
Thanksgiving Day	Fourth Thursday in November
Christmas Day	December 25

Standard Design	The standard design shall observe the same holidays specified for the proposed design.

5.3 Thermal Zones

A thermal zone is a space or collection of spaces having similar space-conditioning requirements, the same heating and cooling setpoint, and is the basic thermal unit (or zone) used in modeling the building. A thermal zone will include one or more spaces. Thermal zones may be grouped together, but systems serving combined zones shall be subject to efficiency and control requirements of the combined zones. High-rise residential and non-residential buildings with identical floors served by like systems may be modeled with floor multipliers.

5.3.1 General Information

Thermal Zone Name

Applicability	All projects
Definition	A unique identifier for the thermal zone made up of 50 or fewer alphanumeric characters.

Units	Text
Input Restrictions	None
Standard Design	Not applicable

Thermal Zone Description

Applicability	All projects
Definition	A brief description of the thermal zone that identifies the spaces which make up the thermal zone or other descriptive information. The description should tie the thermal zone to the building plans.
Units	Text
Input Restrictions	None
Standard Design	Not applicable

Thermal Zone Type

Applicability	All projects
Definition	Designation of the thermal zone as directly conditioned space, indirectly conditioned space (i.e., conditioned only by passive heating or cooling from an adjacent thermal zone), or plenum (i.e., unoccupied but partially conditioned as a consequence of its role as a path for returning air).
Units	List: directly conditioned, unconditioned or plenum
Input Restrictions	The default thermal zone type is “directly conditioned.”
Standard Design	The descriptor is identical for the proposed design and standard design.

System Name

Applicability	All projects
Definition	The name of the HVAC system that serves this thermal zone. The purpose of this building descriptor is to link the thermal zone to a system (child points to parent). Software can make this link in other ways.
Units	Text, unique
Input Restrictions	None
Standard Design	The standard design may have a different system mapping if the standard design has a different HVAC type than the proposed design.

Floor Area

Applicability	All projects
Definition	The gross floor area of a thermal zone; including walls and minor spaces for mechanical or electrical services such as chases that are not assigned to other thermal zones.
Units	Square feet (ft^2)
Input Restrictions	The floor area of the thermal zone is derived from the floor area of the individual spaces that make up the thermal zone.
Standard Design	

Same as proposed design

5.3.2 Interior Lighting

Inputs for interior lighting are specified at the space level (see specification below). In those instances when thermal zones contain just one space, the inputs here will be identical to the inputs for the single space that is contained within the thermal zone.

For those instances when a thermal zone contains more than one space, the software shall either model the lighting separate for each space and sum energy consumption and heat gain for each time step of the analysis or it must incorporate some procedure to sum inputs or calculate weighted averages such that the lighting power used at the thermal zone level is equal to the combination of lighting power for each of the spaces contained in the thermal zone.

In some cases, combining lighting power at the space level into lighting power for the thermal zone may be challenging and would have to be done at the level of each time step in the simulation. These cases include:

- A thermal zone that contains some spaces that have daylighting and others that do not.
- A thermal zone that contains spaces with different schedules of operation.
- A thermal zone that contains some spaces that have a schedule adjusted in some way for lighting controls and other spaces that do not.
- Combinations of the above.

5.3.3 Receptacle Loads

Inputs for receptacle and process loads are specified at the space level (see specification below). In those instances when thermal zones contain just one space, the inputs here will be identical to the inputs for the single space that is contained within the thermal zone.

For those instances when a thermal zone contains more than one space, the software shall either model the receptacle and process loads separate for each space and sum energy consumption and heat gain for each time step of the analysis or it must incorporate some procedure to sum inputs or calculate weighted averages such that the receptacle and process loads used at the thermal zone level are equal to the combination of receptacle and process loads for each of the spaces contained in the thermal zone.

When the spaces contained in a thermal zone have different schedules, combining receptacle and process loads from the space level may be challenging and would have to be done at the level of each time step in the simulation. See discussion above on lighting.

5.3.4 Occupants

Inputs for occupant loads are specified at the space level (see specification below). In those instances when thermal zones contain just one space, the inputs here will be identical to the inputs for the single space that is contained within the thermal zone.

For those instances when a thermal zone contains more than one space, the software shall either model the occupant loads separate for each space and the heat gain for each time step of the analysis or it must incorporate some procedure to sum inputs or calculate weighted averages such that the occupant loads used at the thermal zone level are equal to the combination of occupant loads for each of the spaces contained in the thermal zone.

When the spaces contained in a thermal zone have different occupant schedules, rolling up occupant loads from the space level may be challenging and would have to be done at the level of each time step in the simulation. Spaces with differences in full-load equivalent operating hours of more than 40 hours per week shall not be combined in a single zone. See discussion above on lighting.

5.3.5 Natural Ventilation

Natural ventilation may be modeled for a thermal zone in the proposed design when there are automatic controls that maintain natural ventilation openings open whenever the space is occupied. If zone temperature setpoints are maintained using only natural ventilation, the heating, cooling and ventilation systems may be shut off.

If the proposed design results in excessive unmet load hours in cooling for any naturally ventilated zone, then the user must define and specify a capacity for a Supplementary DX Cooling Unit (Section 5.7.5.2) to serve each zone (with excessive UMLH). If the proposed design results in excessive unmet load hours in heating for any naturally ventilated zone, the user must define a Supplementary DX Cooling Unit with gas furnace heating to serve each zone with excessive UMLH in heating.

The standard design model shall not include natural ventilation.

Natural Ventilation Method	
Applicability	All thermal zones with natural ventilation
Definition	The method used to model natural ventilation. The choices will depend on the capabilities of the energy simulation program.
Units	List: choices depend on the capabilities of the energy simulation program.
Input Restrictions	When the building is conditioned solely by natural ventilation, the proposed design must have automatic controls that maintain natural ventilation whenever the space is occupied. When the building has mechanical ventilation and cooling in conjunction with natural ventilation (operable windows), natural ventilation may only be allowed in the model if the building has interlocks on operable windows or other means of automatic controls (automatic window controls). Natural ventilation that is used for spaces as a means of ventilation only (no space conditioning) may only be specified in the compliance model if there are controls to ensure that the required minimum ventilation is maintained during occupied hours. Operable windows that are opened and closed manually do not qualify for this modeling option.
Standard Design	The standard design is not modeled with natural ventilation.

Air Flow Rate	
Applicability	All projects with natural ventilation that use a method that require the specification of an air flow rate
Definition	The rate of air flow through the thermal zone when the natural ventilation system is operating
Units	Air changes per hour or cfm
Input Restrictions	Documentation shall be provided supporting the air flow rate for the proposed design. The air flow rate shall meet mandatory ventilation requirements of the Standard.
Standard Design	The standard design is not modeled with natural ventilation.

Minimum Indoor Temperature	
Applicability	All projects with natural ventilation or mixed mode ventilation with automatic controls

Definition	The minimum indoor temperature below which natural ventilation is disabled
Units	Degrees F
Input Restrictions	Fixed at 71°F for mixed mode ventilation and 70°F for natural ventilation
Standard Design	Not applicable

Maximum Indoor Temperature	
Applicability	All projects with natural ventilation or mixed mode ventilation with automatic controls
Definition	The maximum indoor temperature below which natural ventilation is disabled
Units	Degrees F
Input Restrictions	Fixed at 74°F for mixed mode ventilation and 76°F for natural ventilation
Standard Design	Not applicable.

Minimum Outdoor Temperature	
Applicability	All projects with natural ventilation or mixed mode ventilation with automatic controls
Definition	The minimum outdoor temperature below which natural ventilation is disabled
Units	Degrees F
Input Restrictions	Fixed at 55°F
Standard Design	Not applicable

Maximum Outdoor Temperature	
Applicability	All projects with natural ventilation or mixed mode ventilation with automatic controls
Definition	The maximum outdoor temperature above which natural ventilation is disabled
Units	Degrees F
Input Restrictions	Fixed at 75°F
Standard Design	Not applicable

5.3.6 Thermal Mass

This set of building descriptors characterize the thermal mass that is not explicitly captured by the definition of exterior surfaces and interior partitions.

Thermal Response Characteristics	
Applicability	All projects
Definition	This building descriptor only addresses the building contents. The thermal mass associated with floors, interior walls, and other building envelope components is derived from the thermal properties and materials that make up these components. However, if interior partitions are not explicitly entered (see below) their effect may be captured with this input. The thermal capacitance of the building contents are typically specified in terms of the composite weight of the building contents in lb/ft² or absolute lb. In this instance, the

	software assumes an average specific heat for the contents. This input can also be specified as the mass of the contents multiplied times the specific heat of the contents. The latter method would be a summation, since each item may have a different specific heat.
Units	lb/ft² or lb
Input Restrictions	As designed
Standard Design	The interior thermal mass in the standard design shall be the same as the proposed design.

Furniture and Contents

Applicability	All projects
Definition	A specification of the mass and heat capacity of furniture and other elements in the interior of the building. This includes information about the coverage and weight of furniture in the space as well as how much of the floor is covered by furniture. The latter affects how much of the solar gains that enters the space is directed to the floor with delayed heat gain and how much becomes a more instantaneous load.
Units	Data structure
Input Restrictions	As designed
Standard Design	The interior thermal mass and modeling assumptions in the standard design shall be the same as the proposed design.

5.4 Space Uses

Each thermal zone discussed above may be subdivided into spaces. This section presents the building descriptors that relate to the space uses. Space uses and the defaults associated with them are listed in Appendix 5.4A. Every thermal zone shall have at least one space, as defined in this section. Daylit spaces should generally be separately defined.

5.4.1 General Information

Space Type

Applicability	All projects
Definition	For identifying space type, either the complete building method or area category method may be used. If lighting compliance is not performed, use either approach, but actual LPDs cannot be entered for the spaces – the LPDs of the building match the standard design. The allowed building types in complete building category or space types in area category are available from Appendix 5.4A. The building or space type determines the following baseline inputs: Number of occupants (occupant density) Equipment Power Density Lighting Power Density

Hot Water Load

Ventilation Rate

Schedules (from Appendix 5.4B)

Units	List
Input Restrictions	Only selections shown in the Appendix 5.4A may be used. For unconditioned spaces, the user must enter “Unconditioned” as the occupancy and ventilation, internal loads and uses are set to zero. Compliance software shall require the user to identify if lighting compliance is performed (lighting plans are included or have already been submitted).
Standard Design	Same as proposed.
Standard Design, Existing Buildings	Same as proposed

Floor Area

Applicability:	All projects that use the space-by-space area category classification method (see above)
Definition:	The floor area of the space. The area of the spaces that make up a thermal zone shall sum to the floor area of the thermal zone.
Units	Square feet (ft^2)
Input Restrictions:	Area shall be measured to the outside of exterior walls and to the center line of partitions.
Standard Design	Area shall be identical to the proposed design.
Standard Design, Existing Buildings	Same as proposed

5.4.2 Infiltration

Infiltration Method

Applicability	All projects
Definition	Energy simulation programs have a variety of methods for modeling uncontrolled air leakage or infiltration. Some procedures use the effective leakage area which is generally applicable for small residential scale buildings. The component leakage method requires the user to specify the average leakage through the building envelope per unit area (ft^2). Other methods require the specification of a maximum rate, which is modified by a schedule.
Units	List: effective leakage area, component leakage, air changes per hour
Input Restrictions	For the purpose of California Compliance and Reach, the component leakage area is prescribed; a fixed infiltration rate shall be specified and calculated as a leakage per area of exterior envelope, including the *gross area* of exterior walls and fenestration, , but excluding roofs and exposed floors.
Standard Design	The infiltration method used for the standard design shall be the same as the

proposed design.

Infiltration Data

Applicability All projects

Definition Information needed to characterize the infiltration rate in buildings. The required information will depend on the infiltration method selected above. For the effective leakage area method, typical inputs are leakage per exterior wall area in ft² or other suitable units and information to indicate the height of the building and how shielded the site is from wind pressures. Only zones with exterior wall area are assumed to be subject to infiltration.

Units A *data structure* is required to define the effective leakage area model,

Input Restrictions For the purpose of California Compliance and Reach, infiltration shall be calculated each hour using Equation 1:

$$Infiltration = I_{design} \cdot F_{schedule} \cdot \left(A + B \cdot \left|t_{zone} - t_{odb}\right| + C \cdot ws + D \cdot ws^2\right) \quad (1)$$

where:

Infiltration = zone infiltration airflow (m³/s-m²)
I_{design} = design zone infiltration airflow (m³/s-m²)
$F_{schedule}$ = fractional adjustment from a prescribed schedule, based on HVAC availability schedules in Appendix 5.4B(unitless)
t_{zone} = zone air temperature (°C)
t_{odb} = outdoor dry bulb temperature (°C)
ws = the windspeed (m/s)
A = overall coefficient (unitless)
B = temperature coefficient (1/°C)
C = windspeed coefficient (s/m)
D = windspeed squared coefficient (s²/m²)

For the proposed design, I_{design} shall have a fixed value of 0.0448 cfm/ft^2 (0.000228 m³/s-m²) times the gross wall area exposed to ambient outdoor air. A, B and D shall be fixed at zero. C shall be fixed at 0.10016 hr/mile (0.224 s/m).

Standard Design The standard design shall use the equation listed above, with coefficients A,B,D set to 0. C shall be set to 0.10016 hr/mile (0.224 s/m). I_{design} shall be 0.0448 cfm/ft^2.

Infiltration Schedule

Applicability When an infiltration method is used that requires the specification of a schedule

Definition With the ACH method and other methods (see above), it may be necessary to specify a schedule that modifies the infiltration rate for each hour or time step of the simulation. Typically the schedule is either on or off, but can also be fractional.

Units Data structure: schedule, fractional

Input Restrictions The infiltration schedule shall be prescribed based on the HVAC System operating schedules from Appendix 5.4B. The infiltration schedule shall be set equal to 1 when the HVAC system is scheduled off, and 0.25 when the HVAC system is scheduled on. This is based on the assumption that when the HVAC system is on it brings the pressure of the interior space above the pressure of the exterior, decreasing the infiltration of outside air. When the HVAC system is off, interior pressure drops below exterior pressure and infiltration increases.

Standard Design

The infiltration schedule for the standard design shall be set equal to 1 when the HVAC system is scheduled off, and 0.25 when the HVAC system is scheduled on.

5.4.3 Occupants

For space level information on occupancy, lighting and plug load schedules, as well as occupant density, allowed lighting power density, Appendix 5.4A provides a table of allowed space types.

Number of Occupants	
Applicability	All projects
Definition	The number of persons in a space. The number of persons is modified by an hourly schedule (see below), which approaches but does not exceed 1.0. Therefore, the number of persons specified by the building descriptor is similar to design conditions as opposed to average occupancy.
Units	The number of persons may be specified in an absolute number, ft²/person, or persons/1000 ft².
Input Restrictions	The number of occupants is prescribed, and the values are given by Space Type in Appendix 5.4A,
Standard Design	The number of occupants must be identical for both the proposed and baseline design cases.
Standard Design, Existing Buildings	The number of occupants must be identical for both the proposed and baseline design cases.

Occupant Heat Rate	
Applicability	All projects
Definition	The sensible and latent heat produced by each occupant in an hour. This depends on the activity level of the occupants and other factors. Heat produced by occupants must be removed by the air conditioning system as well as the outside air ventilation rate and can have a significant impact on energy consumption.
Units	Btu/h specified separately for sensible and latent gains
Input Restrictions	The occupant heat rate is prescribed for California Compliance and Reach.
Standard Design	The occupant heat rate for the baseline building shall be the same as the proposed design.
Standard Design, Existing Buildings	Same as proposed

Occupancy Schedule	
Applicability	All projects
Definition	The occupancy schedule modifies the number of occupants to account for expected operational patterns in the building. The schedule adjusts the heat contribution from occupants to the space on an hourly basis to reflect time-dependent usage patterns.

	The occupancy schedule can also affect other factors such as outside air ventilation, depending on the control mechanisms specified.
Units	Data structure: schedule, fractional.
Input Restrictions	The occupant schedule is prescribed for California Compliance and Reach. For California Compliance and Reach, an appropriate schedule from Appendix 5.4B shall be used.
Standard Design	Occupancy schedules are identical for proposed and baseline building designs.
Standard Design, Existing Buildings	Same as proposed

5.4.4 Interior Lighting

The building descriptors in this section are provided for each lighting system. Typically a space will have only one lighting system, but in some cases, it could have two or more. Examples include a general and task lighting system in offices or hotel multi-purpose rooms that have lighting systems for different functions. It may also be desirable to define different lighting systems for areas that are daylit and those that are not.

Lighting Classification Method

Applicability	Each space in the building
Definition	Indoor lighting power can be specified using the complete building method, area category method or the tailored method. Complete building method can be used for building types listed in Appendix 5.4A. Parking garage portion of the building shall be considered as a separate space. This method cannot be combined with other lighting classification methods described in this section. Area category method can be used for all areas of the building with space types listed in Appendix 5.4A. This method can be used by itself or with the tailored lighting method. Tailored lighting method can be used for spaces with primary function listed in Table 140.6-D of the Standards. The tailored lighting method is intended to accommodate special lighting applications. The tailored lighting method can be used by itself for all areas of the building or with the area category method. For a given area only one classification type can be used.
Units	List
Input Restrictions	Only Complete Building, Area Category or Tailored Lighting are allowed. Use of the Complete Building method triggers an Exceptional Condition requires that the compliance software include reporting of special documentation requirements. Also, a single lighting designation in the Complete Building may not be used for any nonresidential building with an attached parking garage.
Standard Design	Same as proposed.
Standard Design, Existing Buildings	Same as proposed.

Table 10- Lighting Specification

Options: Lighting Classification Method	Complete Building Method	Area Category Method	Tailored Lighting Method
Allowed combinations with other lighting classification methods	None	May be combined with Tailored method	May be combined with Area Category Method
Allowed Regulated lighting power types	General Lighting Power	General Lighting Power Custom Lighting Power	General Lighting Power Custom Lighting Power
Allowed Trade-offs	None	General lighting between conditioned spaces using area category method General lighting between conditioned spaces using area category and tailored method.	General lighting between conditioned spaces using tailored method General lighting between conditioned spaces using tailored and area category method
Exception: With the Area Category method, custom lighting power can be used only if the tailored lighting method is not used in any area of the building.			

Regulated Interior Lighting Power

Applicability All projects when lighting compliance is performed

Definition Total connected lighting power for all regulated interior lighting power. This includes the loads for lamps and ballasts. The total regulated interior lighting power is the sum of general lighting power and applicable custom lighting power. Calculation of lighting power for conditioned spaces is done separately from unconditioned spaces.

Lighting in unconditioned spaces can be modeled, but total lighting power in unconditioned spaces is not enforced in the compliance software. Lighting in unconditioned spaces must follow prescriptive compliance, and must be documented on appropriate compliance forms. No tradeoffs are allowed between lighting in conditioned spaces and lighting in unconditioned spaces.

Units Watts

Input Restrictions Derived – not a user input. The proposed value is:

a) For the area category method, the sum of the proposed *General Lighting Power* and the proposed *General Lighting Exceptional Power for all conditioned spaces*

b) For the tailored lighting method: the sum of the proposed *General Lighting Power* and the proposed *Custom Lighting Power for all conditioned spaces*.

When lighting compliance is not performed, the lighting power may not be entered and is set equal to the lighting level of the baseline building, which is set to the levels for the selected occupancy from Appendix 5.4A.

Standard Design For spaces without special task lighting, wall display lighting or similar requirements, this input will be the same as the general lighting power. See the general lighting power building descriptor for details.

With the area category and tailored method regulated interior lighting power for each space will be the sum of general lighting power and allowed custom lighting power.

For alterations where less than 40 luminaires have been modified the standard design is the existing lighting condition before the alteration. If 40 or more luminaires have been modified, the prescriptive requirements for new construction apply.

General Lighting Power

Applicability	All spaces or projects
Definition	General lighting power is the power used by installed electric lighting that provides a uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect, and also known as ambient lighting.
Units	Watts
Input Restrictions	As designed. For spaces without special task lighting, wall display lighting or similar requirements, this input will be the same as the regulated lighting power. Trade-offs in general lighting power is allowed between spaces all using the area category method, between spaces all using the tailored lighting method and between spaces that use area category and tailored methods. See Table Lighting Specification Options.
Standard Design	With the space-by-space area category method, general lighting power is the product of the lighting power densities for the space type from Appendix 5.4A and the floor areas for the corresponding conditioned spaces. With the tailored lighting method, general lighting power is the product of the lighting power density for the primary function type in Table 140.6-D of the Standards and floor area of the space. The lighting power density is given as a function of room cavity ratio (RCR) and interior illumination level in Table 140.6-G. *No interpolation is allowed for this table.* The general lighting power in the tailored method is calculated by the following steps: Step 1. Determine illumination level from Table 140.6-D by matching the Primary Function Area in Table 140.6-D with the space type in Appendix 5.4A. Step 2. Calculate the room cavity ratio (RCR) by using the applicable equation in Table 140.6-F. Rectangular Rooms: RCR = 5 x H x (L+W) / (L x W) Irregular Rooms: RCR = 2.5 x H x P / A Where: L =Length of room; W = Width of room; H =Vertical distance from the work plane to the centerline of the lighting fixture; P = Perimeter of room, and A = Area of room Step 3. Determine the general lighting in the space(s) using the tailored method by a look-up in Table 140.6-G, where the general lighting LPD is a function of illuminance level and RCR. No interpolation is allowed for this table. A space between two illuminance levels (for example, 150 lux) uses the applicable LPD from the next lower illuminance level (100 lux).
Standard Design, Existing Buildings	When the lighting status is "existing" (and unaltered) for the space, the standard design is the same as the existing, proposed design. When the lighting status is 'Altered' for the space, (a) If the installed lighting power density (LPD)<=85% of standard design LPD: Standard Design LPD same as the Proposed Design,

(b) If the installed lighting power density (LPD) > 85% of standard design LPD: Standard Design LPD same as New Construction.

General Lighting Exceptional Power

Applicability Spaces that use the area category method; note that some exceptional allowances are only applicable to certain space types – see Table 140.6-C of the Standards

Definition The Standards provide an additional lighting power allowance for special cases. Each of these lighting system cases is treated separately as "use-it-or-lose-it" lighting: the user receives no credit (standard design matches proposed), but there is a maximum power allowance for each item). There are eight lighting power allowances, as defined in the Standards Table 140.6-C footnotes:

Units Data structure: this input has 8 data elements:

1) Specialized task work, laboratory (W/ft^2)

2) Specialized task work, other approved areas (W/ft^2)

3) Ornamental lighting (W/ft^2)

4) Precision commercial and industrial work (W/ft^2)

5) White board or chalk board lighting (W/linear foot)

6) Accent, display and feature lighting (W/ft^2)

7) Decorative Lighting (W/ft^2)

8) Videoconferencing studio lighting (W/ft^2)

Input Restrictions As designed.

Standard Design The standard design General Lighting Exceptional Power is given by the following equation:

$$GLEP_{std} = \sum_{i=1}^{8} \min(GLEP_{prop,i} \times GLETA \ , GLEA_i \times GLETA_i)$$

Where

$GLEP_{std}$ = the General Lighting Exceptional Power of the standard design,

$GLEP_{prop,i}$ = the proposed General Lighting Exception Power of the footnote allowance i in the data structure above, or in the footnotes to Table 140.6-C of the Standards,

$GLEA_i$ = the General Lighting Exceptional Allowance, which is the maximum allowed added lighting power in the rightmost column in Table 140.6-C of the Standards. These allowances are, for GLEA1 through GLEA8, 0.2 W/ft^2, 0.5 W/ft^2, 0.5 W/ft^2, 1.0 W/ft^2, 5.5 W/linear foot, 0.3 W/ft^2, 0.2 W/ft^2 and 1.5 W/ft^2, respectively.

$GLETA_i$ = the General Lighting Exceptional Task Area for the ith exception, where the exception number corresponds to the area category exception number in the footnotes to Table 140.-C of the Standards.

General Lighting Exceptional Task Area

Applicability Spaces that use area category method

Definition The area associated each of the exceptional lighting allowances in the General Lighting Exceptional Power building descriptor.

Units ft^2

Input Restrictions

	As designed, but cannot exceed the floor area of the space
Standard Design	Same as proposed
Standard Design, Existing Buildings	Same as proposed

White Board Length

Applicability	Spaces that use area category method and take General Lighting Exceptional Power allowance #5
Definition	The linear length of the white board or chalk board in feet
Units	ft
Input Restrictions	As designed.
Standard Design	Same as proposed
Standard Design, Existing Buildings	Same as proposed

Custom Lighting Power

Applicability All spaces or projects that use the tailored lighting method

Definition Custom lighting power covers lighting sources that are not included as general lighting. These include task lighting, display lighting and other specialized lighting designated in the footnotes to Table 140.6-C and lighting systems in Table 140.6-D of the Standards This lighting must be entered separately from the general lighting because it is not subject to tradeoffs.

Software shall allow the user to input a custom lighting input for the allowed lighting system. Custom lighting power cannot be used with the complete building method. If area category method is used, custom lighting power cannot be used if the tailored method is used for any area of the building. See Table Lighting Specification Options for details.

Units Watts

Input Restrictions As designed.

Standard Design Same as proposed, but subject to the maximum limits specified in the footnotes to Table 140.6-C and Table 140.6-D of the Standards. For spaces using the tailored method, the maximum allowed custom power is defined by the following procedure:

The Standard Design Custom Lighting Power is calculated by the sum of the following four terms:

1) The product of the standard design Wall Display Power and the standard design Wall Display Length,
2) The product of the standard design Floor and Task Lighting Power and the standard design Floor and Task Lighting Area,
3) The product of the standard design Ornamental and Special Effect Lighting Power and the standard design Ornamental and Special Effect Lighting Area,
4) The product of the standard design Very Valuable Display Case Power and the standard design Very Valuable Display Case Area,

Standard Design, Existing Buildings	For alterations where less than 40 luminaires have been modified, the baseline is the existing lighting condition before the alteration. If 40 or more luminaires have been modified, the custom lighting power for the baseline is the same as proposed, but subject to the limits specified in the footnotes to Table 140.6-C of the Standards.

Wall Display Power

Applicability	All spaces that use the tailored lighting method
Definition	The lighting power allowed for wall display, as specified in Standards Table 140.6-D, column 3
Units	W/ft
Input Restrictions	As designed.
Standard Design	The standard design lighting power is the lesser of the proposed design wall display power or the limit specified in Table 140.6-D for the applicable space type.
Standard Design, Existing Buildings	Same as proposed

Wall Display Length

Applicability	All spaces that use the tailored lighting method
Definition	The horizontal length of the wall display lighting area using the tailored method for the space.
Units	ft
Input Restrictions	As designed, but this value of this input cannot exceed the floor area of the space.
Standard Design	Same as proposed
Standard Design, Existing Buildings	Same as proposed

Floor and Task Lighting Power

Applicability	All spaces that use the tailored lighting method
Definition	The lighting power allowed for wall display, as specified in Standards Table 140.6-D, column 4
Units	W/ft^2
Input Restrictions	As designed.
Standard Design	The standard design floor and task lighting power is the lesser of the proposed design floor and task lighting power or the limit specified in Table 140.6-D, column 4, for the applicable space type.
Standard Design, Existing Buildings	Same as proposed

Floor and Task Lighting Area

Applicability	All spaces that use the tailored lighting method
Definition	

	The lighting area that is served by the floor and task lighting defined using the tailored method for the space.
Units	ft^2
Input Restrictions	As designed, but this value of this input cannot exceed the floor area of the space.
Standard Design	Same as proposed
Standard Design, Existing Buildings	Same as proposed

Ornamental and Special Effect Lighting Power

Applicability	All spaces that use the tailored lighting method
Definition	The lighting power allowed for ornamental and special effect lighting, as specified in Standards Table 140.6-D, column 5
Units	W/ft^2
Input Restrictions	As designed.
Standard Design	The standard design floor and task lighting power is the lesser of the proposed design floor and task lighting power or the limit specified in Table 140.6-D, column 5, for the applicable space type.
Standard Design, Existing Buildings	Same as proposed

Ornamental and Special Effect Lighting Area

Applicability	All spaces that use the tailored lighting method
Definition	The lighting area that is served by the ornamental and special effect lighting defined using the tailored method for the space.
Units	ft^2
Input Restrictions	As designed, but this value of this input cannot exceed the floor area of the space.
Standard Design	Same as proposed
Standard Design, Existing Buildings	Same as proposed

Very Valuable Display Case Lighting Power

Applicability	All spaces that use the tailored lighting method and that have very valuable display cases holding Very Valuable Merchandise as defined in the Standards.
Definition	The lighting power allowed for very valuable display case lighting, as specified in Standards section 140.6(c)3L.
Units	W/ft^2
Input Restrictions	As designed.
Standard Design	The standard design Very Valuable Display Case Lighting Power is the lesser of the proposed design very valuable display case lighting power or the following limit: The lesser of: a) The product of the area of the primary function and 0.8 W/ft^2, and

b) The product of the area of the display case and 12 W/ft^2.

Standard Design, Existing Buildings	Same as proposed

Very Valuable Display Case Lighting Area

Applicability	All spaces that use the tailored lighting method
Definition	The area of the very valuable display case(s) in plan view.
Units	ft^2
Input Restrictions	As designed, but this value of this input cannot exceed the floor area of the space.
Standard Design	Same as proposed
Standard Design, Existing Buildings	Same as proposed

Non-Regulated Interior Lighting Power

Applicability	All projects
Definition	For California, §140.6(a)3 of the energy efficiency standards identifies non-regulated (exempted) lighting.
Units	W/ft^2 or Watts
Input Restrictions	As designed. The non-regulated lighting power should be cross-referenced to the type of exception and to the construction documents. The default for non-regulated lighting power is zero.
Standard Design	The non-regulated interior lighting in the baseline building shall be the same as the proposed design.
Standard Design, Existing Buildings	Same as proposed

Lighting Schedules

Applicability	All projects
Definition	Schedule of operation for interior lighting power used to adjust the energy use of lighting systems on an hourly basis to reflect time-dependent patterns of lighting usage.
Units	Data structure: schedule, fractional
Input Restrictions	The lighting schedule is prescribed for California Compliance and California Reach. An appropriate schedule from Appendix 5.4B shall be used.
Standard Design	The baseline building shall use the same lighting schedules as the proposed design.
Standard Design, Existing Buildings	Same as proposed

Tailored Lighting Illumination Height

Applicability	Spaces that have special tailored lighting power allowances
Definition	The illumination height is the vertical distance from the work plane to the luminaire.

	This is used in the calculation of the Room Cavity Ratio.
Units	ft
Input Restrictions	As designed
Standard Design	Same as proposed. The baseline general lighting power for the space that uses the tailored lighting method is calculated by one of the following equations:

$$RCR = \frac{5 \times H \times (L + W)}{L \times W} \qquad \text{for rectangular rooms}$$

$$RCR = \frac{2.5 \times H \times P}{A} \qquad \text{for irregular-shaped rooms}$$

Where the illumination height defined for this input is H, the room length is L, width is W, perimeter is P and room area is A.

The allowed general lighting power for the tailored method is a function of the room cavity ratio and the space illumination level (in lux), and specified in Table 140.6-G of the Standards.

Standard Design, Existing Buildings	Same as for new construction

Mounting Height Above Floor

Applicability	Spaces that have wall display or floor display lighting and tailored lighting power allowances
Definition	The mounting height of wall display lighting above the floor. To qualify for an additional lighting allowance, all luminaires must be located at or above the specified height.
Units	List: one of three choices: <12 ft, 12-16 ft, > 16 ft
Input Restrictions	As designed. The entered value maps to Table 140.6-E of the Standards, that provides an adjustment multiplier for the tailored lighting wall power allowance in Table 140.6-D. The multiplier is 1.15 if the mounting height is 12' to 16', and 1.30 if greater than 16'. The compliance software must perform input processing to perform the necessary requirements.
Standard Design	Same as proposed.
Standard Design, Existing Buildings	Same as for new construction

Fixture Type

Applicability	All interior light fixtures
Definition	The type of lighting fixture, which is used to determine the Light Heat Gain Distribution
Units	List: one of three choices: Recessed with Lens, Recessed/Downlight, Not in Ceiling
Input Restrictions	As designed.
Standard Design	

	Recessed/Downlight
Standard Design, Existing Buildings	Recessed/Downlight

Luminaire Type

Applicability	All interior light fixtures
Definition	The type of lighting luminaire, which is used to determine the Light Heat Gain Distribution. The Dominant Luminaire type determines the daylight dimming characteristics, when there are more than one type of luminaire in the space.
Units	List: Linear Fluorescent, CFL, Incandescent, LED, Metal Halide, Mercury Vapor, High Pressure Sodium
Input Restrictions	As designed.
Standard Design	Linear Fluorescent
Standard Design, Existing Buildings	Linear Fluorescent

Light Heat Gain Distribution

Applicability	All projects
Definition	The distribution of the heat generated by the lighting system that is directed to the space, the plenum, the HVAC return air, or to other locations. This input is a function of the luminaire type and location. Luminaires recessed into a return air plenum contribute more of their heat to the plenum or the return air stream if the plenum is used for return air; while pendant mounted fixtures hanging in the space contribute more of their heat to the space. Common luminaire type/space configurations are listed in Table 3, Chapter 18, 2009 ASHRAE Handbook of Fundamentals, summarized in Table 11 below. Typically the data will be linked to list of common luminaire configurations similar to Table 11 so that the user chooses a luminaire type category and heat gain is automatically distributed to the appropriate locations.
Units	List (of luminaire types) or data structure consisting of a series of decimal fractions that assign heat gain to various locations.
Input Restrictions	Default values listed in Table 11 shall be used as a default when the luminaire categories apply... Where lighting fixtures having different heat venting characteristics are used within a single space, the wattage weighted average heat-to-return-air fraction shall be used.
Standard Design	The baseline building shall use the values in the Table below for *Recessed fluorescent luminaires without lens*.
Standard Design, Existing Buildings	Same as for new construction

Table 11 – Light Heat Gain Parameters for Typical Operating Conditions
Based on Table 3, Chapter 18, 2009 ASHRAE Handbook – Fundamentals

Fixture Type	Luminaire Type	Return Type	Space Fraction	Radiative Fraction
Recessed with Lens	Linear Fluorescent	Ducted/Direct	1.00	0.67
		Plenum	0.45	0.67
Recessed/Downlight	Linear Fluorescent	Ducted/Direct	1.00	0.58
		Plenum	0.69	0.58
	CFL	Ducted/Direct	1.00	0.97
		Plenum	0.20	0.97
	Incandescent	Ducted/Direct	1.00	0.97
		Plenum	0.75	0.97
	LED	Ducted/Direct	1.00	0.97
		Plenum	0.20	0.97
	Metal Halide	Ducted/Direct	1.00	0.97
		Plenum	0.75	0.97
Non In Ceiling	Linear Fluorescent	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	CFL	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	Incandescent	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	LED	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	Metal Halide	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	Mercury Vapor	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54
	High Pressure Sodium	Ducted/Direct	1.00	0.54
		Plenum	1.00	0.54

In this table, the Space Fraction is the fraction of the lighting heat gain that goes to the space; the radiative fraction is the fraction of the heat gain to the space that is due to radiation, with the remaining heat gain to the space due to convection.

Power Adjustment Factors (PAF)

Applicability All projects

Definition Automatic controls that are not already required by the baseline standard and which reduce lighting power more or less uniformly over the day can be modeled as power adjustment factors. Power adjustment factors represent the percent reduction in lighting power that will approximate the effect of the control. Models account for such controls by multiplying the controlled watts by (1 – PAF).

Eligible California power adjustment factors are defined in Table 140.6-A. Reduction in lighting power using the PAF method can be used only for non-residential controlled general lights. Only one PAF can be used for a qualifying lighting system unless additions are allowed in Table 140.6.A of the standards. Controls for which PAFs are eligible are listed in Table 140.6-A of the California energy efficiency standards and include:

- Occupancy Sensing Controls for qualifying enclosed spaces and open offices
- Demand Control – Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal for qualifying building types.
- Manual and multiscene programmable dimming for qualifying area types.
- Manual Dimming plus multi-level occupancy sensor for qualifying area types.

Units List: eligible control types (see above) linked to PAFs

Input Restrictions PAF shall be fixed for a given control and area type

Standard Design, Existing Buildings PAF is zero

5.4.5 Daylighting Control

This group of building descriptors is applicable for spaces that have daylighting controls or daylighting control requirements.

California prescribes a modified version of the split flux daylighting methods to be used for compliance. This is an *internal daylighting method* because the calculations are automatically performed by the simulation engine. For top-lighted or sidelit daylighted areas, California Compliance prescribes an internal daylighting model consistent with the split flux algorithms used in many simulation programs. With this method the simulation model has the capability to model the daylighting contribution for each hour of the simulation and make an adjustment to the lighting power for each hour, taking into account factors such as daylighting availability, geometry of the space, daylighting aperture, control type and the lighting system. The assumption is that the geometry of the space, the reflectance of surfaces, the size and configuration of the daylight apertures, and the light transmission of the glazing are taken from other building descriptors.

Daylight Control Requirements

Applicability All spaces with exterior fenestration

Definition The extent of daylighting controls in skylit and sidelit areas of the space

Units List;

when the installed general lighting power in the primary daylit zone exceeds 120W, daylighting controls are required, per the Title 24 mandatory requirements.

Input Restrictions As designed

Standard Design, Existing Buildings

For nonresidential spaces, when the installed general lighting power in the skylit or primary sidelit daylit zone exceeds 120W, daylighting controls are required in the primary daylit zone, per the Title 24 mandatory requirements.

For parking garages, when the installed general lighting power in the primary sidelit or secondary sidelit daylit zone exceeds 120W, daylighting controls are required, per the Title 24 mandatory requirements. Luminaires located in daylit transition zones or dedicated ramps are exempt from this requirement.

For nonresidential spaces, daylighting controls are specified when the installed general lighting power in the skylit, primary sidelit, or secondary sidelit daylit zone(s) exceeds 120W.

For parking garages, when the installed general lighting power in the primary sidelit or secondary sidelit daylit zone exceeds 120W, daylighting controls are required. Luminaires located in daylit transition zones or dedicated ramps are exempt from this requirement.

When lighting systems in an existing altered building are not modified as part of the alteration, daylighting controls are the same as the Proposed Design.

When an alteration increases the area of a lighted space, increases lighting power in a space or when luminaires are modified in a space where proposed design lighting power density is greater than 85% of the standard design LPD, daylighting control requirements are the same as for New Construction

Skylit, Primary and Secondary Daylighted Area

Applicability All daylighted spaces

Definition The floor area that is daylighted. The skylit area is the portion of the floor area that gets daylighting from a skylight. Two types of sidellit daylighted areas are recognized. The primary daylighted area is the portion that is closest to the daylighting source and receives the most illumination. The secondary daylighted area is an area farther from the daylighting source, but still receives useful daylight.

The primary daylight area for sidelighting is a band near the window with a depth equal to the distance from the floor to the top of the window and width equal to window width plus 0.5 times window head height wide on each side of the window opening. The secondary daylight area for sidelighting is a band beyond the primary daylighted area that extends a distance double the distance from the floor to the top of the window and width equal to window width plus 0.5 times window head height wide on each side of the window opening. Area beyond a permanent obstruction taller than 6 feet should not be included in the primary and secondary daylight area calculation.

The skylit area is a band around the skylight well that has a depth equal to the 70% of the ceiling height from the edge of the skylight well. The geometry of the skylit daylit area will be the same as the geometry of the skylight. Area beyond a permanent obstruction taller than 50% of the height of the skylight from the floor should not be included in the skylit area calculation.

Double counting due to overlaps is not permitted. If there is an overlap between Secondary and Primary or Skylit areas, the effective daylit area used for determining Reference position shall be the area minus the overlap.

Units ft^2

Input Restrictions The daylit areas in a space are derived using other modeling inputs like dimensions of the fenestration and ceiling height of the space.

Standard Design The daylit areas in the baseline building are derived from other modeling inputs, including the dimensions of the fenestration and ceiling height of the space. Daylit area calculation in the standard design is done after Window to wall ratio and Skylight to roof ratio rules in Section 5.5.7 of this manual are applied.

Standard Design, Existing Buildings Same as new construction, when skylights are added or replaced and general lighting altered.

Installed General Lighting Power in the Primary and Skylit Daylit Zone

Applicability All spaces

Definition The installed lighting power of general lighting in the primary and skylit daylit zone. The primary and skylit daylit zone shall be defined on the plans and be consistent with the definition of the primary and skylit daylit zone in the Standards. Note that a separate building descriptor, Fraction of Controlled Lighting, defines the fraction of the lighting power in the space that is controlled by daylighting.

Units Watts

Input Restrictions As designed.

Standard Design The Installed lighting power for the standard design is the product of the primary daylit area and the lighting power density (LPD) for general lighting in the space.

Standard Design, Existing Buildings Same as new construction when skylights are added, replaced and general lights are altered.

Installed General Lighting Power in the Secondary Daylit Zone

Applicability All spaces

Definition The installed lighting power of general lighting in the secondary daylit zone. The secondary daylit zone shall be defined on the plans and be consistent with the definition of the secondary daylit zone in the Standards. Note that a separate building descriptor, Fraction of Controlled Lighting, defines the fraction of the lighting power in the space that is controlled by daylighting.

Units Watts

Input Restrictions As designed.

Standard Design The Installed lighting power for the standard design is the product of the secondary daylit area and the lighting power density (LPD) for general lighting in the space.

Standard Design, Existing Buildings Same as new construction when skylights are added, replaced and general lights are altered.

Reference Position for Illuminance Calculations

Applicability All spaces or thermal zones – depending on which object is the primary container for daylighting controls.

Definition

The position of the two daylight reference points within the daylit space. Lighting controls are simulated so that the illuminance at the reference position is always maintained at or above the illuminance setpoint. Thus, for step switching controls, the combined daylight illuminance plus uncontrolled electric light illuminance at the reference position must be greater than the setpoint illuminance before the controlled lighting can be dimmed or tuned off for stepped controls. Similarly, dimming controls will be dimmed so that the combination of the daylight illuminance plus the controlled lighting illuminance is equal to the setpoint illuminance.

Preliminary reference points for primary and secondary daylit areas are located at the farthest end of the daylit area aligned with the center of the each window. For skylit area, the preliminary reference point is located at the center of the edge of the skylit area closest to the centroid of the space. In each case, the Z – coordinate of the reference position (elevation) shall be located 2.5 feet above the floor.

Up to two final reference positions can be selected from among the preliminary reference positions identified in for each space.

Units

Data structure

Input Restrictions

The user does not specify the reference position locations; reference positions are automatically calculated by the compliance software based on the procedure outlined below. Preliminary reference positions are each assigned a Relative Daylight Potential (RDP) which estimates the available illuminance at each position, and the final reference position selection is made based on the RDP.

Relative Daylight Potential (RDP): an estimate of daylight potential at a specific reference position. This is NOT used directly in the energy simulation, but it used to determine precedence for selecting the final reference points. The relative daylight potential is calculated as a function of Effective Aperture, Azimuth, Illuminance Setpoint and the type (skylit, primary sidelit, or secondary sidelit) of the associated daylit zone. RDP is defined as:

$$RDP = C_1 * EA_{dz} + C_2 * SO + C_3$$

Where:

C1, C2 and C2 are selected from the following table.

	Skylit Daylit Zones			Primary Sidelit Daylit Zones			Secondary Sidelit Daylit Zones		
Illuminance Setpoint	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
≤ 200 lux	3,927	0	3,051	1,805	-0.40	3,506	7,044	-3.32	1,167
≤ 1000 lux	12,046	0	-421	6,897	-7.22	475	1,512	-2.88	-22
> 1000 lux	5,900	0	-516	884	-5.85	823	212	-0.93	57

Illuminance Setpoint: this is defined by the user, and is entered by the user, subject to the limits specified in Appendix 5.4A, determined from the space type.

Source Orientation (SO): the angle of the outward facing normal of the daylight source's parent surface projected onto a horizontal plane, expressed as degrees from South. This is not a user input but is calculated from the geometry of the parent surface. For Skylights, the Source Orientation is not applicable. For vertical fenestration SO is defined:

SO = AbsoluteValue(180 – Azimuth)

Where:

Azimuth is defined as the azimuth of the parent object containing the fenestration associated with the preliminary reference point.

Effective Aperture (EA): for the purpose of this calculation, effective aperture represents the effectiveness of all sources which illuminate a specific reference position in contributing to the daylight available to the associated daylit zone. In cases where daylit zones from multiple fenestration objects intersect, the effective aperture of an individual daylit zone is adjusted to account for those intersections according to the following rules:

- For skylit and primary sidelit daylit zones, intersections with other skylit or primary sidelit daylit zones are considered
- For secondary sidelit daylit zones, intersections with any toplit or sidelit (primary or secondary) daylit zones are considered.

Effective aperture is defined as follows:

$$EA_{dz} = (VT_{fdz}*A_{fdz} + \sum(F_i*VT_i*A_i)) / A_{dz}$$

Where: primary

EA_{dz} is the combined effective aperture of all daylight sources illuminating a specific daylit zone.

VT_{fdz} is the user specified visible transmittance of the fenestration object directly associated with the daylit zone

A_{fdz} is the area of the fenestration object directly associated with the daylit zone

VT_i is the user specified visible transmittance of the fenestration object associated with each intersecting daylit zone

A_i is the area of the fenestration object directly associated with each intersecting daylit zone

F_i is the fraction of intersecting area between the daylit zone in question and each intersecting daylit zone:

$$F_i = A_{intersection}/A_{dzi}$$

A_{dzi} is the area of each intersecting daylit zone (including area that might fall outside a space or exterior boundary)

A_{dz} is the area of the daylit zone (including area that might fall outside a space or exterior boundary).

1. **First Reference Position:**

   Select the preliminary reference point with the highest relative daylight potential (RDP) from amongst all preliminary reference points located within either top or primary sidelit daylit zones. If multiple reference points have identical RDPs, select the reference point geometrically closest to the centroid of the space.

2. **Second Reference Position:**

   Select the preliminary reference point with the highest RDP from amongst all remaining preliminary reference points located within either top or primary sidelit daylit zones.If multiple reference points have identical RDPs, select the reference point geometrically closest to the centroid of the space.

Standard Design Reference positions for the standard design shall be selected using the same procedure as those selected for the proposed design.

Standard Design, Existing Buildings The additions of lighting or alteration of lighting in spaces trigger the daylighting control requirements whenever the total installed lighting in the daylit zone is 120 W or greater, and the reference positions shall be determined in the same manner as with new construction. This is only applicable when alterations or additions to the lighting in an existing building trigger daylighting control requirements.

Illumination Adjustment Factor

Applicability All daylighted spaces

Definition Recent studies have shown that the split flux interreflection component model used in many simulation programs overestimates the energy savings due to daylighting, particularly deep in the space. A set of two adjustment factors is provided, one for the primary daylit zone and one for the secondary daylit zone.

For simulation purposes, the input daylight illuminance setpoint will be modified by the Illuminance Adjustment factor as follows:

$\text{LIGHT-SET-PT}_{adj} = \text{LIGHT-SET-PT} \times \text{Adjustment Factor}$

Units unitless

Input Restrictions As per prescribed values for space type in Appendix 5.4A

Standard Design The baseline building illumination adjustment factors shall match the proposed.

Standard Design, Existing and Altered Same as for new construction, when skylights are added, replaced and general light altered.

Fraction of Controlled Lighting

Applicability Daylighted spaces

Definition The fraction of the general lighting power in the (daylighted) primary and skylit daylit zone, or secondary sidelit daylit zone that is controlled by daylighting controls.

Units Numeric: fraction for primary and skylit daylit zone, and fraction for secondary zone

Input Restrictions As designed for secondary daylit areas. If the proposed design has no daylight controls in the secondary daylit area the value is set to 0 for the general lights in the secondary daylit area. Primary and skylit daylit area fraction of controlled general lighting shall be as designed when the Daylight Control Requirements building descriptor indicates that they are not required, and shall be 1 when controls are required.

Standard Design When daylight controls are required according to the Daylight Control Requirements building descriptor in either the primary daylit and skylit zone, or the secondary daylit zone, or both, the Fraction of Controlled Lighting shall be 1.

Standard Design, Existing Buildings Same as new construction when skylights are added, replaced and general lights are altered.

Daylighting Control Type

Applicability Daylighted spaces.

Definition The type of control that is used to control the electric lighting in response to daylight available at the reference point. The options are:

- Stepped Switching Controls vary the electric input power and lighting output power in discrete equally spaced steps. At each step, the fraction of light output is equal to the fraction of rated power.
- Continuous Dimming controls have a fraction to rated power to fraction of rated output that is a linear interpolation of the *minimum power fraction* at the *minimum diming light fraction* to rated power (power fraction = 1.0) at full light output. See Figure 8.
- Continuous Dimming + Off controls are the same as continuous dimming controls except that these controls can turn all the way off when none of the controlled light output is needed. See Figure 8.

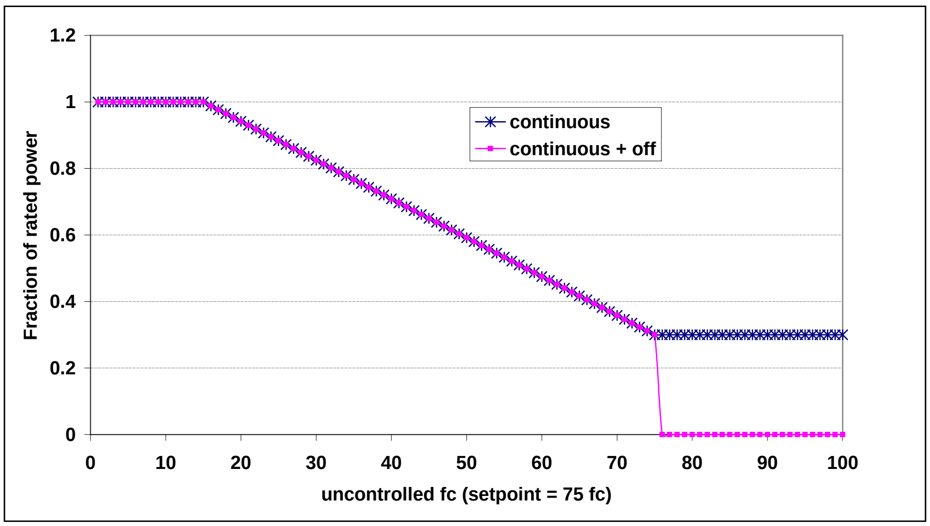


Figure 8 – Example Dimming Daylight Control

Units List (see above)

Input Restrictions As designed.

Standard Design Baseline does not have a daylighting control (continuous).

Standard Design Same as for new construction, when skylights are added, replaced and general lighting altered.

Minimum Dimming Power Fraction

Applicability Daylit spaces

Definition The minimum power fraction when controlled lighting is fully dimmed. Minimum power fraction = (Minimum power) / (Full rated power). See Figure 8.

Units Numeric: fraction

Input Restrictions As designed, specified from Luminaire Type (not a user input)

Standard Design Baseline building uses continuous dimming control with a minimum dimming power fraction of:

Light Source	Power Fraction	Light output Fraction
LED	0.1	0.1
Linear Fluorescent	0.2	0.2
Mercury Vapor	0.3	0.2
Metal Halide	0.45	0.2
High Pressure sodium	0.4	0.2
CFL	0.4	0.2
Incandescent	0.5	0.2

Where the Controlled Luminaire Type, input by the user, determines the Minimum Dimming Power Fraction

Standard Design, Existing Buildings Same as for new construction, when skylights are added, replaced and general lighting altered.

Minimum Dimming Light Fraction

Applicability Daylighted and dimming controls

Definition Minimum light output of controlled lighting when fully dimmed. Minimum light fraction = (Minimum light output) / (Rated light output). See Figure 8.

Units Numeric: fraction

Input Restrictions As designed

Standard Design Baseline building uses continuous dimming control with a minimum dimming light fraction of:

Light Source	Power Fraction	Light output Fraction
LED	0.1	0.1
Linear Fluorescent	0.2	0.2
Mercury Vapor	0.3	0.2
Metal Hallide	0.45	0.2
High Pressure sodium	0.4	0.2
CFL	0.4	0.2
Incandescent	0.5	0.2

Standard Design, Existing Buildings

Standard Design, Existing Buildings

Where the Controlled Luminaire Type, input by the user, determines the Minimum Dimming Power Fraction

Same as for new construction, when skylights are added, replaced and general lighting altered.

Number of Control Steps

Applicability Daylighted spaces that use stepped controls

Definition Number of control steps~~.~~ For step dimming, identifies number of steps that require fraction of rated light output and rated power fraction.

Units Numeric: integer

Input Restrictions Integer 1 or 4 for primary and skylit daylit areas, as designed for secondary daylit areas.

Standard Design Not applicable.

Same as for new construction, when skylights are added, replaced and general lighting altered.

Controlled Luminaire Type

Applicability Daylit spaces

Definition The predominant luminaire type in the daylit control zone. This is defined as the type of luminaire that has the most installed wattage in the daylit control zone. This input defines which dimming curve to use (from a lookup table)

Units List

Metal halide

Compact fluorescent

Linear fluorescent

LED

Input Restrictions As designed

Standard Design Same as proposed.

5.4.6 Receptacle Loads

Receptacle loads contribute to heat gains in spaces and directly use energy.

Receptacle Power

Applicability All building projects

Definition Receptacle power is power for typical general service loads in the building. Receptacle power includes equipment loads normally served through electrical receptacles, such as office equipment and printers, but does not include either task lighting or equipment used for HVAC purposes. Receptacle power values are slightly higher than the largest hourly receptacle load that is actually modeled because the receptacle power values are modified by the receptacle schedule, which approaches but does not exceed 1.0.

Units Total power (W) or the space or power density (W/ft^2)

Compliance software shall also use the following prescribed values to specify the latent heat gain fraction and the radiative/convective heat gain split.

For software that specifies the fraction of the heat gain that is lost from the space, this fraction shall be prescribed at 0.

Receptacle Power heat gain fractions:

Radiative = 0.20, Latent = 0.00, Convective = 0.80

Gas Equipment Power Heat Gain Fractions:

Radiative = 0.15, Latent = 0, Convective = 0

Prescribed to values from Appendix 5.4A

Standard Design Input Restrictions	Same as Proposed
Standard Design, Existing Buildings	Same as for new construction

Receptacle Schedule	
Applicability	All projects
Definition	Schedule for receptacle power loads used to adjust the intensity on an hourly basis to reflect time-dependent patterns of usage.
Units	Data structure: schedule, fraction
Input Restrictions	The schedule is prescribed in appendix 5.4A.
Standard Design	Schedules for the baseline building shall be identical to the proposed design.
Existing Buildings	Same as for new construction

5.4.7 Commercial Refrigeration Equipment

Commercial refrigeration equipment includes the following:

- Walk-in refrigerators
- Walk-in freezers
- Refrigerated casework

Walk-in refrigerators and freezers typically have remote condensers. Some refrigerated casework has remote condensers, while some have a self-contained condenser built into the unit. Refrigerated casework with built-in condensers rejects heat directly to the space while remote condensers reject heat in the remote location, typically on the roof or behind the building.

Refrigerated casework can be further classified by the purpose, the type of doors and, when there are no doors, the configuration: horizontal, vertical or semi-vertical. USDOE has developed standards for refrigerated casework. Table 12 shows these classifications along with the standard level of performance, expressed in kWh/d, which depends on the class of equipment, the total display area, and the volume of the casework.

Table 12 – USDOE Requirements for Refrigerated Casework (kWh/d)

TABLE I–1—STANDARD LEVELS FOR COMMERCIAL REFRIGERATION EQUIPMENT

Equipment class [2]	Standard level * ** (kWh/day) ***	Equipment class	Standard level * ** (kWh/day)
VOP.RC.M	0.82 × TDA + 4.07	VCT.RC.I	0.66 × TDA + 3.05
SVO.RC.M	0.83 × TDA + 3.18	HCT.RC.M	0.16 × TDA + 0.13
HZO.RC.M	0.35 × TDA + 2.88	HCT.RC.L	0.34 × TDA + 0.26
VOP.RC.L	2.27 × TDA + 6.85	HCT.RC.I	0.4 × TDA + 0.31
HZO.RC.L	0.57 × TDA + 6.88	VCS.RC.M	0.11 × V + 0.26
VCT.RC.M	0.22 × TDA + 1.95	VCS.RC.L	0.23 × V + 0.54
VCT.RC.L	0.56 × TDA + 2.61	VCS.RC.I	0.27 × V + 0.63
SOC.RC.M	0.51 × TDA + 0.11	HCS.RC.M	0.11 × V + 0.26
VOP.SC.M	1.74 × TDA + 4.71	HCS.RC.L	0.23 × V + 0.54
SVO.SC.M	1.73 × TDA + 4.59	HCS.RC.I	0.27 × V + 0.63
HZO.SC.M	0.77 × TDA + 5.55	SOC.RC.L	1.08 × TDA + 0.22
HZO.SC.L	1.92 × TDA + 7.08	SOC.RC.I	1.26 × TDA + 0.26
VCT.SC.I	0.67 × TDA + 3.29	VOP.SC.L	4.37 × TDA + 11.82
VCS.SC.I	0.38 × V + 0.88	VOP.SC.I	5.55 × TDA + 15.02
HCT.SC.I	0.56 × TDA + 0.43	SVO.SC.L	4.34 × TDA + 11.51
SVO.RC.L	2.27 × TDA + 6.85	SVO.SC.I	5.52 × TDA + 14.63
VOP.RC.I	2.89 × TDA + 8.7	HZO.SC.I	2.44 × TDA + 9.
SVO.RC.I	2.89 × TDA + 8.7	SOC.SC.I	1.76 × TDA + 0.36
HZO.RC.I	0.72 × TDA + 8.74	HCS.SC.I	0.38 × V + 0.88

* TDA is the total display area of the case, as measured in the Air-Conditioning and Refrigeration Institute (ARI) Standard 1200–2006, Appendix D.

** V is the volume of the case, as measured in ARI Standard 1200–2006, Appendix C.

*** Kilowatt hours per day.

[2] For this rulemaking, equipment class designations consist of a combination (in sequential order separated by periods) of: (1) An equipment family code (VOP=vertical open, SVO=semivertical open, HZO=horizontal open, VCT=vertical transparent doors, VCS=vertical solid doors, HCT=horizontal transparent doors, HCS=horizontal solid doors, or SOC=service over counter); (2) an operating mode code (RC=remote condensing or SC=self contained); and (3) a rating temperature code (M=medium temperature (38 °F), L=low temperature (0 °F), or I=ice-cream temperature (− 15 °F)). For example, "VOP.RC.M" refers to the "vertical open, remote condensing, medium temperature" equipment class. See discussion in section V.A.2 and chapter 3 of the TSD, market and technology assessment, for a more detailed explanation of the equipment class terminology. See Table IV–2 for a list of the equipment classes by category.

Walk-in refrigerators and freezers are not covered by the USDOE standards and test procedures. Title-24 default values for these are given in Table 13. These values are expressed in W/ft² of refrigerator or freezer area. This power is assumed to occur continuously. Some walk-ins have glass display doors on one side so that products can be loaded from the back. Glass display doors increase the power requirements of walk-ins. Additional power is added when glass display doors are present. The total power for walk-in refrigerators and freezers is given in Equation (1).

$$P_{Walk-in} = \left(\mathrm{A}_{\mathrm{Ref}} \cdot \mathrm{PD}_{\mathrm{Ref}} + N_{\mathrm{Ref}} \cdot D_{\mathrm{Ref}}\right) + \left(\mathrm{A}_{\mathrm{Frz}} \cdot \mathrm{PD}_{\mathrm{Frz}} + N_{\mathrm{Frz}} \cdot D_{\mathrm{Frz}}\right) \quad (1)$$

Where:

$P_{Walk\text{-}in}$ is the estimated power density for the walk-in refrigerator or freezer in (W)

A_{xxx} the area of the walk-in refrigerator or freezer (ft²)

N_{xxx} the number of glass display doors (unitless)

PD_{xxx} the power density of the walk-in refrigerator or freezer taken from Table 13 (W/ft²)

D_{xxx} the power associated with a glass display door for a walk-in refrigerator or freezer (W/door)

$_{xxx}$ subscript indicating a walk-in freezer or refrigerator (Ref or Frz)

Table 13 – Default Power for Walk-In Refrigerators and Freezers (W/ft²)
Source: These values are determined using the procedures of the Heatcraft Engineering Manual, Commercial Refrigeration Cooling and Freezing Load Calculations and Reference Guide, August 2006. The EER is assumed to be 12.39 for refrigerators and 6.33 for Freezers. The specific efficiency is assumed to be 70 for refrigerators and 50 for freezers. Operating temperature is assumed to be 35 F for refrigerators and -10 F for freezers.

Floor Area	Refrigerator	Freezer
100 ft² or less	8.0	16.0
101 ft² to 250 ft²	6.0	12.0
251 ft² to 450 ft²	5.0	9.5
451 ft² to 650 ft²	4.5	8.0
651 ft² to 800 ft²	4.0	7.0
801 ft² to 1,000 ft²	3.5	6.5
More than 1,000 ft²	3.0	6.0
Additional Power for each Glass Display Door	105	325
Note:		

Refrigeration Modeling Method

Applicability All buildings that have commercial refrigeration for cold storage or display

Definition The method used to estimate refrigeration energy and to model the thermal interaction with the space where casework is located. Two methods are included in this manual:

- **Title 24 defaults**. With this method, the power density values provided in Appendix 5.4A[1] are used; schedules are assumed to be continuous operation.
- **USDOE performance ratings**. With this method, the energy modeler takes inventory of the refrigerated casework in the rated building and sums the rated energy use (typically in kWh/day). Walk-in refrigerators and freezers shall use the defaults from Equation (1) and the values from Table 13. All refrigeration equipment is then assumed to operate continuously.

The remaining building descriptors in this section apply to buildings that use either the Title-24 defaults or the USDOE performance ratings.

Units List (see above)

Input Restrictions None. For California Compliance, the *Title 24 defaults* shall be used. Otherwise, there are no input restrictions.

Standard Design Same as proposed

Standard Design, Existing Buildings Same as for new construction

Refrigeration Power

Applicability All buildings or spaces that have commercial refrigeration for cold storage or display.

Definition Commercial refrigeration power is the average power for all commercial refrigeration equipment, assuming constant year-round operation. Equipment includes walk-in refrigerators and freezers, open refrigerated casework, and closed refrigerated

[1] See Table C-43, p. 146 of NREL/TP-550-41956, Methodology for Modeling Building Energy Performance across the Commercial Sector, Technical Report, Appendix C, March 2008. The values in this report were taken from Table 8-3 of the California Commercial End-Use Survey, Consultants Report, March 2006, CEC-400-2006-005

	casework. It does not include residential type refrigerators used in kitchenettes or refrigerated vending machines. These are covered under *receptacle power*.
Units	W/ft^2
Input Restrictions	With the *Title 24 defaults* method, the values in Appendix 5.4A are prescribed. These values are multiplied times the floor area of the rated building to estimate the refrigeration power. With the *USDOE performance ratings* method, refrigeration power is estimated by summing the kWh/day for all the refrigeration equipment in the space and dividing by 24 hours. The refrigeration power for walk-in refrigerators and freezers is added to this value.
Standard Design	Refrigeration power is the same as the proposed design when the Title 24 defaults are used. When the *USDOE performance ratings* method is used, refrigeration power for casework shall be determined from Table 12; the power for walk-in refrigerators and freezers shall be the same as the proposed design.
Standard Design, Existing Buildings	Same as for new construction

Remote Condenser Fraction

Applicability All buildings that have commercial refrigeration for cold storage or display and use the *Title 24 defaults* or *USDOE performance ratings* methods

Definition The fraction of condenser heat that is rejected to the outdoors. For self-contained refrigeration casework, this value will be zero. For remote condenser systems, this value is 1.0. For combination systems, the value should be weighted according refrigeration capacity.

For refrigeration with self-contained condensers and compressors, the heat that is removed from the space is equal to the heat that is rejected to the space, since the evaporator and condenser are both located in the same space. There may be some latent cooling associated with operation of the equipment, but this may be ignored with the *Title 24 defaults* or *USDOE performance ratings* methods. The operation of self-contained refrigeration units may be approximated by adding a continuously operating electric load to the space that is equal to the energy consumption of the refrigeration units. Self-contained refrigeration units add heat to the space that must be removed by the HVAC system.

When the condenser is remotely located, heat is removed from the space but rejected outdoors. In this case, the refrigeration equipment functions in a manner similar to a continuously running split system air conditioner. Some heat is added to the space for the evaporator fan, the anti-fog heaters and other auxiliary energy uses, but refrigeration systems with remote condensers remove more heat from the space where they are located than they add. The HVAC system must compensate for this imbalance.

For remotely located condensers using the *Title 24 defaults* or *USDOE performance ratings* methods, the heat that is removed from the space is determined as follows:

$$Q = \left[(1 - F) \times kW - (F \times kW \times COP)\right] \times 3.413 \qquad (2)$$

Where:

Q	The rate of heat removal from the space due to the continuous operation of the refrigeration system (kBtu/h). A negative number means that heat is being removed from the space; a positive number means that heat is being added.

kW	The power of the refrigeration system determined by using the *Title 24 defaults* or the *USDOE performance ratings* method (kW)
F	The remote condenser fraction (see building descriptor below) (unitless)
COP	The coefficient of performance of the refrigeration system (unitless)

The simple approach outlined above assumes that there is no latent cooling associated with the refrigeration system. The heat addition or removal resulting from the above equation can be modeled in a number of ways, to accommodate the variety of calculation engines available. It can be scheduled if the engine can accommodate a heat removal schedule. It can be modeled as a separate, constantly running air conditioner, if the engine can accommodate two cooling systems serving the same thermal zone. Other modeling techniques are acceptable as long as they are thermodynamically equivalent.

Units Fraction

Input Restrictions None

Standard Design Same as the proposed design

Standard Design, Existing Buildings Same as for new construction

Refrigeration COP

Applicability All buildings that have commercial refrigeration for cold storage or display and use the *Title 24 defaults* or *USDOE performance ratings* methods

Definition The coefficient of performance of the refrigeration system. This is used only to determine the heat removed or added to the space, not to determine the refrigeration power or energy.

Units Fraction

Input Restrictions This value is prescribed to be 3.6 for refrigerators and 1.8 for freezers.[2]

Standard Design Same as the proposed design

Standard Design, Existing Buildings Same as for new construction

Refrigeration Schedule

Applicability All buildings that have commercial refrigeration for cold storage or display

Definition The schedule of operation for commercial refrigeration equipment. This is used to convert refrigeration power to energy use.

Units Data structure: schedule, fractional

Input Restrictions Continuous operation is prescribed.

Standard Design Same as the proposed design

[2] These values are consistent with the assumptions for the default values for walk-ins, which assume an EER of 12.39 for refrigerators and 6.33 for freezers.

Standard Design, Existing Buildings Same as for new construction

5.4.8 Elevators, Escalators and Moving Walkways

Elevators, escalators and moving walkways account for 3% to 5% of electric energy use in buildings.[3] Buildings up to about five to seven stories typically use hydraulic elevators because of their lower initial cost. Mid-rise buildings commonly use traction elevators with geared motors, while high-rise buildings typically use gearless systems where the motor directly drives the sheave. The energy using components include the motors and controls as well as the lighting and ventilation systems for the cabs.

Elevators are custom designed for each building. In this respect they are less like products than they are engineered systems, e.g. they are more akin to chilled water plants where the engineer chooses a chiller, a tower, pumping and other components which are field engineered into a system. The main design criteria are safety and service. Some manufacturers have focused on energy efficiency of late and introduced technologies such as advanced controls that optimize the position of cars for minimum travel and regeneration motors that become generators when a loaded car descends or an empty car rises. These technologies can result in 35% to 40% savings.[4]

The motors and energy using equipment is typically located within the building envelope so it produces heat that must be removed by ventilation or by air conditioning systems. In energy models, a dedicated thermal zone (elevator shaft) will typically be created and this space can be indirectly cooled (from adjacent spaces) or positively cooled.

Little information is known on how to model elevators. As engineered systems, the model would need information on the number of starts per day, the number of floors, motor and drive characteristics, and other factors. Some work has been done to develop and categorize energy models for elevators;[5] however a simple procedure is recommended based on a count of the number of elevators, escalators and moving walkways in the building. This data is shown in Table 14. [6]

Table 14 – Unit Energy Consumption Data for Elevators, Escalators and Moving Walkways[7]

	Elevators		Escalators and Moving Walkways	
Mode	Power (W)	Annual Hours	Power (W)	Annual Hours
Active	10,000	300	4,671	4,380
Ready	500	7,365	n.a.	0
Standby	250	1,095	n.a.	0
Off	0	0	0	4,380
Typical Annual Energy Use	7,000 kWh/y		20,500 kWh/y	

Elevator/Escalator Power

Applicability All buildings that have commercial elevators, escalator, or moving walkways

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3 Sachs, Harvey M., Opportunities for Elevator Energy Efficiency Improvements, American Council for an Energy Efficiency Economy, April 2005

4 Ibid.

5 Al-Sharif, Lutfi, Richard Peters and Rory Smith, Elevator Energy Simulation Model, Elevator World, November 2005, Volume LII, No11

6 TIAX, Commercial and Residential Sector Miscellaneous Electricity consumption: Y20005 and Projections to 2030, Final Report to the U.S. Department of Energy's Energy Information Administration (EIA) and Decision Analysis Corporation (DAC), September 22, 2006, Reference Number D0366.

7 The TIAX report does not give energy consumption data for moving walkways. For the purposes of this manual, it is assumed to be equal to escalators.

Definition	The power for elevators, escalators and moving walkways for different modes of operation. Elevators typically operate in three modes: active (when the car is moving passengers), ready (when the lighting and ventilation systems are active but the car is not moving), and standby (when the lights and ventilation systems are off). Escalators and moving walkways are either active or turned off.
Units	W/unit
Input Restrictions	The power values from Table 14 for different modes of operation are prescribed for the proposed design.
Standard Design	Same as the proposed design
Standard Design, Existing Buildings	Not applicable

Elevator/Escalator Schedule	
Applicability	All buildings that have commercial elevators, escalator, or moving walkways
Definition	The schedule of operation for elevators, escalators, and moving walkways. This is used to convert elevator/escalator power to energy use.
Units	Data structure: schedule, state
Input Restrictions Standard Design	The operating schedule is prescribed California Compliance and Reach. For California Compliance, an appropriate schedule from Appendix 5.4B shall be used. If values other than those shown in Appendix 5.4B are used, this will be reported as a condition requiring an Exceptional Condition Review by a third party reviewer
Standard Design	Same as the proposed design
Standard Design, Existing Buildings	Not applicable

5.4.9 Process, Gas

Commercial gas equipment includes the following:

- Ovens
- Fryers
- Grills
- Other equipment

The majority of gas equipment is located in the space and may contribute both sensible and latent heat. Gas equipment is typically modeled by specifying the rate of peak gas consumption and modifying this with a fractional schedule. Energy consumption data for gas equipment is only beginning to emerge.

Because of these limits, the procedure for commercial gas is limited. The procedure consists of prescribed power and energy values for use with both the proposed design and the baseline building. No credit for commercial gas energy efficiency features is offered.

The prescribed values are provided in Appendix 5.4A. Schedules are defaulted to be continuous operation.

Gas Equipment Power	
Applicability	All buildings that have commercial gas equipment

Definition	Commercial gas power is the average power for all commercial gas equipment, assuming constant year-round operation.
Units	Btu/h-ft²
	Compliance software shall also use the following prescribed values to specify the latent heat gain fraction and the radiative/convective heat gain split.
	For software that specifies the fraction of the heat gain that is lost from the space, this fraction shall be prescribed at 0.
	Gas Equipment Power Heat Gain Fractions:
	Radiative = 0.15, Latent = 0, Convective = 0
Input Restrictions	The values in Appendix 5.4A are prescribed.
Standard Design	Same as the proposed design
Standard Design, Existing Buildings	Not applicable

Gas Equipment Schedule

Applicability	All buildings that have commercial gas equipment
Definition	The schedule of operation for commercial gas equipment. This is used to convert gas power to energy use.
Units	Data structure: schedule, fractional
Input Restrictions	Continuous operation is prescribed.
Standard Design	Same as the proposed design
Standard Design, Existing Buildings	Not applicable

Gas Equipment Location

Applicability	All buildings that have commercial gas equipment
Definition	The assumed location of the gas equipment for modeling purposes. Choices are in the space or external.
Units	List (see above)
Input Restrictions	As designed.
Standard Design	Same as the proposed design
Standard Design, Existing Buildings	Not applicable

Radiation Factor

Applicability	Gas appliances located in the space
Definition	The fraction of heat gain to appliance energy use
Units	Fraction
Input Restrictions	Default value is 0.15. Other values can be used when a detailed inventory of

equipment is known. The override value shall be based on data in Table 5C, Chapter 18, ASHRAE HOF, 2009, or similar tested information from the manufacturer.

Standard Design Same as the proposed design

Standard Design, Existing Buildings Not applicable

Usage Factor

Applicability Gas appliances located in the space

Definition A duty cycle or usage factor to appliance energy use

The radiation factor and usage factor are used together to determine the sensible heat gain to the space:

$Qsens = Qinput \times F_U \times F_R$

Where Qinput is the heat input of the equipment in Btu/h or Btu/h-ft^2,

F_U is the usage factor and

F_R is the radiation factor

Units Fraction

Input Restrictions Default value is 0.70. Other values can be used when a detailed inventory of equipment is known. The override value shall be based on data in Table 5C, Chapter 18, ASHRAE HOF, 2009, or similar tested information from the manufacturer.

Standard Design Same as the proposed design

Standard Design, Existing Buildings Not applicable

Gas Process Loads

Applicability Spaces with process loads

Definition Process load is the gas energy consumption in the conditioned space of a building resulting from an activity or treatment not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy. Process load may include sensible and/or latent components

Compliance software shall model and simulate process loads only if the amount of the process energy and the location and type of process equipment are specified in the construction documents. This information shall correspond to specific special equipment shown on the building plans and detailed in the specifications. The compliance software Compliance Documentation shall inform the user that the compliance software will output process loads including the types of process equipment and locations on the compliance forms.

Units Data structure: sensible (Btu/h), latent (Btu/h)

Input Restrictions Compliance software shall receive input for Sensible and/or Latent Process Load for each zone in the proposed design. The process load input shall include the amount of the process load (Btu/h-ft^2) and the thermal zone where the process equipment is located. The modeled information shall be consistent with the plans and specifications of the building.

Standard Design The standard design shall use the same gas process loads and sensible and latent contribution and radiative/convective split for each zone as the proposed design.

Standard Design, Existing Buildings Same as for new construction

Electric Process Loads

Applicability Spaces with electric process loads

Definition Process load is the electrical energy consumption in the conditioned space of a building resulting from an activity or treatment not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

Data centers loads including transformers, UPS, PDU, server fans and power supplies are considered receptacle loads, not process loads, and the equipment schedules are given in Appendix 5.4B.

Compliance software shall model and simulate process loads only if the amount of the process energy and the location and type of process equipment are specified in the construction documents. This information shall correspond to specific special equipment shown on the building plans and detailed in the specifications. The compliance software Compliance Documentation shall inform the user that the compliance software will output process loads including the types of process equipment and locations on the compliance forms.

Units Data structure: load (kW)

For electric process loads, the radiative fraction shall be defaulted to 0.2 and the convective fraction shall be defaulted to 0.8 by the compliance software. The user may enter other values for the radiative/convective split, but the compliance software shall verify that the values add to 1.

Input Restrictions Compliance software shall receive input for Sensible and/or Latent Process Load for each zone in the proposed design. The process load input shall include the amount of the process load (Btu/h-ft^2) and the thermal zone where the process equipment is located. The modeled information shall be consistent with the plans and specifications of the building.

Standard Design The standard design shall use the same process loads and radiative/convective split for each zone as the proposed design.

Standard Design, Existing Buildings Same as for new construction

Gas Process Load Schedule

Applicability All buildings that have commercial gas equipment

Definition The schedule of operation process load. This is used to convert gas power to energy use.

Units Data structure: schedule, fractional

Input Restrictions As designed.

Standard Design Same as the proposed design

Standard Design, Existing Buildings	Not applicable

Electric Process Load Schedule	
Applicability	All buildings that have commercial gas equipment
Definition	The schedule of operation process load. This is used to convert gas power to energy use.
Units	Data structure: schedule, fractional
Input Restrictions	As designed.
Standard Design	Same as the proposed design
Standard Design, Existing Buildings	Not applicable

5.5 Building Envelope Data

5.5.1 Materials

Energy simulation programs commonly define construction assemblies by listing a sequence of material layers that make up the construction assembly. Appendix 5.5A has a list of standard materials that may be referenced by construction assemblies. Additional materials not listed in Appendix 5.5A may be defined as described below. Alternate methods may be used to define construction assemblies such as specifying the U-factor and optionally, a metric describing thermal mass such as heat capacity (HC). These alternate methods may not require identification of materials. When a material is defined, all of the properties listed below must be defined. Some materials listed in Appendix 5.5A are non-homogeneous, for instance, framing members with insulation in the cavity. Typical construction assemblies and their respective material layers are defined in Reference Appendix JA4. Additionally, the properties of the each material layer can be found in ACM Appendix 5.5A.

Material Name	
Applicability	Opaque constructions
Definition	The name of a construction material used in the exterior envelope of the building
Units	Text: unique
Input Restrictions	Material name is a required input for materials not available from the standard list in ACM Appendix 5.5A. The user may not modify entries for predefined materials.
Standard Design	Not applicable

Density	
Applicability	Opaque constructions
Definition	The density (or mass per unit of volume) of the construction material as documented in Appendix 5.5A.
Units	lb/ft^3
Input Restrictions	

Standard Design	Prescribed from Appendix 5.5A Not applicable

Specific Heat	
Applicability	Opaque constructions
Definition	The specific heat capacity of a material is numerically equal to the quantity of heat that must be supplied to a unit mass of the material to increase its temperature by 1 °F
Units	Btu/lb·°F
Input Restrictions	Prescribed from Appendix 5.5A
Standard Design	Not applicable

Thermal Conductivity	
Applicability	All non-standard materials
Definition	The thermal conductivity of a material of unit thickness is numerically equal to the quantity of heat that will flow through a unit area of the material when the temperature difference through the material is 1 °F.
Units	Btu/h·ft·°F
Input Restrictions	Not applicable
Standard Design	Prescribed from Appendix 5.5A

Thickness	
Applicability	All non-standard materials
Definition	The thickness of a material
Units	ft or in.
Input Restrictions	Prescribed from Appendix 5.5A
Standard Design	Not applicable

5.5.2 Construction Assemblies

For California Compliance and Reach, construction assemblies for the proposed design shall be created by selecting from a library of building construction layers in ACM Appendix 5.5A. The compliance software shall all specify composite layers that consist of both framing and insulation and shall use established methods defined in the ASHRAE Handbook of Fundamentals for calculating effective R-values of composite layers. **Geometry**

The geometry of roofs, walls, floors, doors and fenestration should match the construction documents or as-built drawings as accurately as possible. Unusual curved surfaces such as a dome or semi-circular wall may be approximated by a series of constructions.

Mass Walls

For mass walls, the user first chooses the mass layer from Appendix 5.5A. After that, the user may select an insulating layer from Appendix 5.5A for outside and/or inside the mass wall. **Ballasted Roofs, Vegetated Roofs, Concrete Pavers, and Other Mass Roofs**

An additional layer may be added to the roof construction assembly when thermal mass is used above the roof membrane. This exception is intended to allow ballasted roofs, concrete pavers and other massive elements to be explicitly modeled. To qualify, the weight of the stone ballast, the concrete pavers or other elements must exceed 15 lb/ft^2. The thickness, heat capacity, conductance and density of the additional mass layer shall be based on the measured physical properties of the material. If the surface properties of the additional mass material have been verified through the Cool Roof Rating Council (CRRC), the CRRC reported properties may be used for the proposed design; otherwise, the mass layer shall be modeled with an aged reflectance of 0.10 and an emittance of 0.85.

Assembly Name	
Applicability	All projects
Definition	The name of a construction assembly that describes a roof, wall, or floor assembly. The name generally needs to be unique so it can be referenced precisely by surfaces.
Units	Text: unique
Input Restrictions	Construction name is a required input.
Standard Design	Not applicable

Specification Method	
Applicability	All projects
Definition	The method of describing a construction assembly. The more simple method is to describe the U-factor of the construction assembly which can account for thermal bridging and other factors. However with this method, the time delay of heat transfer through the construction assembly is not accounted for. Generally, with the U-factor method, heat transfer is assumed to occur instantly. The more complex method is to describe the construction assembly as a series of layers, each layer representing a material. With this method, heat transfer is delayed in accord with the thermal mass and other properties of the assembly. For below-grade constructions, a C-factor can be specified; for slab-on-grade constructions, an F-factor is specified.
Units	List: layers, U-factor, C-factor, F-factor
Input Restrictions	The layers method shall be used for all above-grade constructions.
Standard Design	For each construction, the proposed design specification method shall be used.

Layers	
Applicability	All construction assemblies that use the layers method of specification
Definition	A structured list of material names that describe a construction assembly, beginning with the exterior finish and progressing through the assembly to the interior finish. Material names must be from the standard list (Appendix E) or defined (see above) ACM Appendix 5.5A.
Units	List: layers of construction assembly
Input Restrictions	The user is required to describe all layers in the actual assembly and model the proposed design based the layer descriptions.
Standard Design	See building descriptors for Roofs, Exterior Walls, Exterior Floors, Doors, Fenestration and Below Grade Walls.

5.5.3 Roofs

Roof Name	
Applicability	All roof surfaces
Definition	A unique name or code that identifies the roof and ties it to the construction documents submitted for energy code review. It is not mandatory to name roofs.
Units	Text: unique
Input Restrictions	None
Standard Design	None

Roof Type	
Applicability	All roof surfaces
Definition	A roof classification defined in the Standards. This descriptor can be derived from other building descriptors and it may not be necessary for the software user to specify it directly.
Units	List: attic and other roofs; metal building roofs; and roofs with insulation entirely above deck metal building, wood framed or other
Input Restrictions	Not applicable for new construction; as designed for existing buildings
Standard Design	All roofs in the baseline building are modeled as “Wood-framed and other”.
Standard Design, Existing Buildings	For existing buildings, the standard design roof type is the same as that for the proposed design.

Roof Geometry	
Applicability	All roofs, required input
Definition	Roof geometry defines the position, orientation, azimuth, tilt, and dimensions of the roof surface. The details of how the coordinate system is implemented may vary between software programs. The data structure for surfaces is described in the reference section of this chapter.
Units	Data structure: surface
Input Restrictions	There are no restrictions other than that the surfaces defined must agree with the building being modeled, as represented on the construction drawings or as-built drawings.
Standard Design	Roof geometry will be identical in the proposed and standard design building designs. For alterations, roof geometry will be fixed, based on one of the building prototypes (office, retail, etc.)

Roof Solar Reflectance	
Applicability	All opaque exterior surfaces exposed to ambient conditions
Definition	The solar reflectance of a material. For roofing materials, the 3-year aged reflectance value from CRRC testing should be used if available.
Units	

Input Restrictions For roofs that are part of new construction, if asphalt shingles or composition shingles are not rated by the Cool Roof Rating Council (CRRC), the default aged solar reflectance shall be equal to 0.08 for asphalt roofs and 0.10 for all other roof types. The default value may be overridden when roof materials are used that have been tested by the (CRRC) and are called for in the construction documents. In cases where the default value is overridden, the user is required to submit documentation identifying the test procedure that was used to establish the non-default values. If the aged CRRC reflectance is not known, the aged CRRC reflectance may be calculated from the initial CRRC reflectance using the following equation:

$\rho_{aged} = 0.2 + \beta \cdot (\rho_{init} – 0.2)$

Where,

ρ_{aged} = the calculated aged reflectance

β = 0.65 for field-applied coatings, 0.7 for all other roof surfaces

ρ_{nit} = the initial CRRC reflectance

Standard Design For new construction, the standard design reflectance is defined in Table 140.3-B for nonresidential buildings, Table 140.3-C for high-rise residential buildings and hotel-motel buildings containing guestrooms, and Table 140.3-D for relocatable classroom buildings.

For alterations to more than 50% of the roof area or roof areas above 2,000 ft^2 the standard design shall be modeled as the more efficient of either the existing conditions or the values required for cool roofs under Section 141.0 of the Standards.

Roof Thermal Emittance

Applicability All opaque exterior surfaces exposed to ambient conditions; this is prescribed for exterior walls at 0.85 and is the as-designed value entered for roofs, with some restrictions.

Definition The thermal emittance of a material. For roofing materials, the 3-year aged emittance value from CRRC testing should be used if available.

Units

Input Restrictions For roofs, new construction: as designed, from CRRC values. If CRRC rating information is not available, the default thermal emittance shall be 0.75.

Standard Design For roofs, new construction, the standard design thermal emittance shall be 0.85.

For alterations to more than 50% of the roof area or roof areas above 2,000 ft^2 the standard design shall be modeled as the more efficient of either the existing conditions or a thermal emittance of 0.85.

Roof Construction

Applicability All roofs, required input

Definition A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for roof construction type.

Units

List: layers

Input Restrictions The area-weighted average of the roof construction assembly U-factors, defined by a series of layers, must be equal to or more efficient than the mandatory U-factor requirements of Section 120.7 of the Standards for new construction, and Section 141.0 of the Standards for alterations. Note that these U-Factor requirements assume an exterior air film of R-0.17 and an interior air film of R-0.61. Each layer specified must be listed in the materials database in the ACM Appendix 5.5A.

New Construction

Metal Building	U – 0.098
Wood Framed and Others	U – 0.075

Additions and Alterations

Roof / Ceiling Insulation	See 141.0(b)2Biii of the Standards

Appropriate R-values for insulation can be calculated using the formula below.

$R_{insulation} = (1/U\text{-factor}) – R_{layer(1)} – R_{layer(2)} – R_{layer(3)} – R_{layer(n)}$

$R_{insulation} = R_{ins.continuous} + R_{ins.framing}$

<u>Ceilings that form the boundary between the modeled building of an additions and alterations project and the existing, unmodeled portion of the building may be modeled as adiabatic roofs (no heat transfer).</u>

Standard Design Roofs in the baseline building are of the type “insulation entirely above deck.” The insulation requirement is determined by climate zone and baseline standard. The baseline building roof construction shall be modeled as layers as defined. See Appendix 5.5B for details.

For new construction, the standard design roof type is ***wood framed and other,*** and the roof is a standing seam metal roof, with the R-value of continuous insulation adjusted to match the prescriptive Standards for wood-framed and other roofs. The U-factor required for roof construction is defined in Table 140.3-B, C or D of the Standards. Programs that model a U-factor shall include an exterior and interior air film resistance. The Standard Design construction is based on JA4-10 Table 4.2.7 and assumes an exterior air film of R-0.17 and an interior air film of R-0.61.

The standard design construction shall include the following layers:

Layer 1	Metal Standing Seam 1/16 in.	R - 0.00
Layer 2	Continuous Insulation	R - Based on Climate Zone
Layer 3	Open Framing + No Insulation	R – 0.00

The value of the Continuous Insulation layer entirely above framing shall be set to achieve the following R-values:

Nonresidential Buildings – Continuous Ins.

Climate Zones 2, 3, 4, 9- 16	R – 24.860
Climate Zones 1, 5:	R - 19.62
Climate Zones 7, 8:	R – 14.15
Climate Zones 6:	R – 12.55

High-Rise Residential Buildings and Hotel / Motel Guestrooms – Continuous Ins.

Climate Zones 2,4,8- 16	R – 34.93
Climate Zone 1	R – 28.63
Climate Zones 3, 5, 7	R – 24.86

For mixed use buildings, the roof standard design requirements shall be determined by which space type (Nonresidential or Residential) is the majority of the floor area of the adjoining conditioned spaces.

For alterations, any approved roof type may be used. The U-factor in the standard design shall be modeled as the more efficient of either the existing conditions or the values stated in Section 141.0 of the Standards. Where applicable, selection shall be based on building type, assembly, and climate zone. A construction of layers shall be defined to yield an equivalent U-factor.

Standard Design, Existing Buildings

For existing buildings, if the roof component is not altered, the standard design roof construction shall match the proposed design roof construction of the existing building. If the roof is altered, the roof component shall meet the prescriptive requirements for new construction for the roof type of the existing building.

The roof type of the existing building is either a metal building roof or a wood-framed or other roof. The standard design roof assemblies for altered roofs are shown below for the appropriate climate zones.

The Reference Appendix JA4 reference and U-factor are provided for reference only. The U-factor does not need to exactly match the JA4 value, but the layer shall match the layer described below.

Alterations Roof Standard Design

***U-factor and JA4 assembly table and cell reference is provided for reference only. The compliance software shall only require that the layers in the construction match those in this table.**

For alterations, any approved roof type may be used. The U-factor in the standard design shall be modeled as the more efficient of either the existing conditions or the values stated in Section 141.0 of the Standards. Where applicable, selection shall be based on building type, assembly, and climate zone. A construction of layers shall be defined to yield an equivalent U-factor.

5.5.4 Exterior Walls

Wall Name

Applicability All walls, optional input

Definition A unique name or code that relates the exterior wall to the design documents. This is an optional input since there are other acceptable ways to key surfaces to the construction documents.

Units Text: unique

Input Restrictions None

Standard Design None

Wall Type

Applicability	All wall surfaces, optional
Definition	One of four categories of above-grade wall assemblies used to determine minimum insulation requirements for walls. The five wall type categories are as follows: a) Mass Light, b) Mass Heavy c) Metal building, c) Metal framing, and Wood framing and other walls. A Mass Light wall is defined as a wall with total heat capacity greater than 7 but less than 15 Btu/ft^2-F. A Mass Heavy wall is defined as a wall with a total heat capacity of 15 Btu/ft^2-F or greater. (Heat capacity is defined as the product of the specific heat in Btu/lb -F, the thickness in ft, and the density in lb/ft^3.)
Units	List: mass light, mass heavy, metal building walls, metal framing walls, and wood framing and other walls
Input Restrictions	This input is required for existing buildings when any wall is altered. This input is not required for new construction.
Standard Design	All walls in the standard design building are modeled as “metal framed.”
Standard Design, Existing Buildings	The existing building standard design Wall Type shall be the same as the proposed.

Wall Geometry

Applicability	All walls, required input
Definition	Wall geometry defines the position, orientation, azimuth, and tilt of the wall surface. The details of how the coordinate system is implemented may vary between simulation engines. The data structure for surfaces is described in the reference section of this chapter.
Units	Data structure: surface
Input Restrictions	As designed
Standard Design	Wall geometry in the standard design building is identical to the proposed design.

Wall Solar Reflectance

Applicability	All opaque exterior surfaces exposed to ambient conditions
Definition	The solar reflectance of a material. For roofing materials, the 3-year aged reflectance value from CRRC testing should be used if available.
Units	
Input Restrictions	For walls and other non-roof surfaces: The value is prescribed to be 0.3.
Standard Design	For walls and other non-roof surfaces: The value is prescribed to be 0.3.

For new construction, the standard design reflectance shall meet the requirements stated in Section 140.3 of the Standards.

For alterations to more than 50% of the roof area or roof areas above 2,000 ft^2 the standard design shall be modeled as the more efficient of either the existing conditions or the values required for cool roofs under Section 141.0 of the Standards.

Wall Thermal Emittance

Applicability	All opaque exterior surfaces exposed to ambient conditions; this is prescribed for exterior walls at 0.85 and is the as-designed value entered for roofs, with some restrictions.
Definition	The thermal emittance of a material. For roofing materials, the 3-year aged emittance value from CRRC testing should be used if available.
Units	
Input Restrictions	For walls and other non-roof surfaces: The value is prescribed to be 0.9. For roofs, new construction: as designed, from CRRC values. If CRRC rating information is not available, the default thermal emittance shall be 0.75.
Standard Design	For walls and other non-roof surfaces, the thermal emittance is 0.90. For roofs, new construction, the standard design thermal emittance shall be 0.85. For alterations to more than 50% of the roof area or roof areas above 2,000 ft^2 the standard design shall be modeled as the more efficient of either the existing conditions or a thermal emittance of 0.85.

Wall Construction

Applicability	All walls that use the Layers method
Definition	A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for wall construction type.
Units	List: Layers
Input Restrictions	The area-weighted average of the wall construction assembly U-factors, defined by a series of layers, must be equal to or more efficient than the mandatory U-factor requirements of Section 120.7 of the Standards for new construction. Note that these U-Factor requirements assume an exterior air film of R-0.17 and an interior air film of R-0.68. Each layer specified, with the exception of composite layers, must be listed in the materials database in the ACM Appendix 5.5A.

New Construction

Metal Building	U – 0.113
Metal Framed	U – 0.105

Light Mass Walls	U – 0.440
Heavy Mass Walls	U – 0.690
Wood Framed and Others	U – 0.110
Spandrel Panels / Glass Curtain Walls	U – 0.280
Additions and Alterations	
Metal Building	U – 0.113
Metal Framed	U – 0.217
Wood Framed and Others	U – 0.110
Spandrel Panels / Glass Curtain Walls	U – 0.280

Appropriate R-values for insulation can be calculated using the formula below.

$R_{insulation}$ = (1/U-factor) – $R_{layer(1)}$ – $R_{layer(2)}$ – $R_{layer(3)}$ – $R_{layer(n)}$

$R_{insulation}$ = $R_{ins.continuous}$ + $R_{ins.framing}$

Walls that form the boundary between the modeled building of an additions and alterations project and the existing, unmodeled portion of the building may be modeled as adiabatic walls (no heat transfer).

Standard Design

The U-factor required for wall construction of the standard design building is defined in Table 140.3-B, C or D of the Standards. Programs that model a U-factor shall use an exterior and interior air film resistance. The Standard Design construction is based on JA4-10 Table 4.3.3 and assumes an exterior air film of R-0.17 and an interior air film of R-0.68.

For ***metal framed*** walls, the standard design construction shall include the following layers:

Layer 1	Stucco – 7/8 in.	R - 0.18
Layer 2	Building Paper	R – 0.06
Layer 3	Continuous Insulation	R - Based on Climate Zone
Layer 4	Closed Framing and No Ins.	R – 0.65
Layer 5	Gypsum Board – 1/2 in.	R – 0.45

The value of the Continuous Insulation layer entirely outside framing shall be set to achieve the following R-values:

Nonresidential Buildings – Continuous Ins.

Climate Zones 1, 6, and 7	R – 8.01
Climate Zones 2, 4, 5, and 8 – 16	R – 13.94
Climate Zones 3	R – 10.01

High-Rise Residential Buildings and Hotel / Motel Guestrooms – Continuous Ins.

Climate Zones 1 and 5	R – 7.33
Climate Zones 2 – 4, and 6 – 16	R – 9.52

For mixed use buildings, that contain both nonresidential and residential spaces, walls adjacent to nonresidential spaces shall use the Nonresidential Buildings standard design construction, and walls adjacent to residential and high-rise residential spaces shall use the high-rise residential standard design construction.

5.5.5 Exterior Floors

Floor Name

Applicability	All floor surfaces
Definition	A unique name or code that relates the exposed floor to the design documents. Exposed floors include floors exposed to the outdoors and floors over unconditioned spaces, but do not include slab-on-grade floors, below grade floors, or interior floors.
Units	Text: unique
Input Restrictions	None
Standard Design	None

Floor Type

Applicability	All exterior floor surfaces, optional
Definition	The category that defines the standard design prescriptive floor requirements.
Units	List: mass, other
Input Restrictions	Not applicable for new construction; either
Standard Design	The standard design building floors shall be of type “other”
Standard Design, Existing Buildings	The standard design building floor type for existing buildings shall be same as proposed.

Floor Geometry

Applicability	All exterior floors, required input
Definition	Floor geometry defines the position, orientation, azimuth, and tilt of the floor surface. The details of how the coordinate system is implemented may vary between software programs. The data structure for surfaces is described in the reference section of this chapter.
Units	Data structure: surface
Input Restrictions	As designed
Standard Design	Standard design building floor geometry is identical to the proposed design.

Floor Construction

Applicability	All floors, required input

Definition	A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for floor construction type. This input applies only to exterior floors that are above grade and exposed to either outdoors or unconditioned space.
Units	List: Layers
Input Restrictions	The area-weighted average of the floor construction assembly U-factors, defined by a series of layers, must be equal to or more efficient than the mandatory U-factor requirements of Section 120.7 of the Standards for new construction, and Section 141.0 of the Standards for alterations. Note that these U-Factor requirements assume an exterior air film of R-0.17 and an interior air film of R-0.92. Each layer specified must be listed in the materials database in the ACM Appendix 5.5A.

New Construction

Raised Mass Floors	U – 0.269
Other Floors	U – 0.071
Heated Slab Floors	Climate Zone (see Section 120.7)

Additions and Alterations

Raised Framed Floors	U – 0.071
Raised Mass Floors in High-rise Res and Hotel Motel	U – 0.111
Raised Mass Floors in Other Occupancies	No Requirement

Appropriate R-values for insulation can be calculated using the formula below.

$R_{insulation} = (1/U\text{-factor}) - R_{layer(1)} - R_{layer(2)} - R_{layer(3)} - R_{layer(n)}$

$R_{insulation} = R_{ins.continuous} + R_{ins.framing}$

Floors that form the boundary between the modeled building of an addition and alteration project and the existing, unmodeled portion of the building may be modeled as adiabatic floors (no heat transfer).

The U-factor required for floor construction is defined in Table 140.3-B, C or D of the Standards. Programs that model a U-factor shall use an exterior and interior air film resistance. The Standard Design construction is based on JA4-10 Table 4.4.5 and assumes an exterior air film of R-0.17 and an interior air film of R-0.92.

For ***metal framed*** floors, the standard design construction shall include the following layers:

Layer 1	Open Framing + No Ins.	R – 0.00
Layer 2	Continuous Insulation	R – Based on Climate Zone
Layer 3	Plywood – 5/8 in.	R – 0.78
Layer 4	Carpet and Pad – 3/4 in.	R – 1.30

The value of the Continuous Insulation layer entirely above or below framing shall be set to achieve the following R-values:

Nonresidential Buildings – Continuous Ins.

Climate Zones 1	R – 17.66
Climate Zones 2, 11, and 14 -16	R – 22.47
Climate Zones 3 – 10, 12, and 13	R – 10.91

High-Rise Residential Buildings and Hotel / Motel Guestrooms – Continuous Ins.

Climate Zones 1, 2, 14, and 16	R – 26.24
Climate Zones 3 – 6, 8 – 13, and 15	R – 22.47
Climate Zones 7	R – 10.91

5.5.6 Doors

Door Name

Applicability	All exterior doors, optional input
Definition	A unique name or code that relates the door to the design documents submitted. Doors that are more than 50% glass are treated as windows and must be determined and entered by using the *Fenestration* building descriptors.
Units	Text: unique
Input Restrictions	None
Standard Design	None

Door Type

Applicability	All exterior doors, required input
Definition	One of two door classifications of either: swinging or non-swinging. Non-swinging are generally roll-up doors. The prescriptive U-factor requirements depend on door type and climate. This building descriptor may be derived from other building descriptors, in which case a specific input is not necessary.
Units	List: swinging or non-swinging
Input Restrictions	The door type shall be consistent with the type of door represented on the construction documents or as-built drawings.
Standard Design	The standard design building door type shall be the same as the proposed design.

Door Geometry

Applicability	All exterior doors
Definition	Door geometry defines the position and dimensions of the door surface relative to its parent wall surface. The azimuth and tilt (if any) of the door is inherited from the parent surface. The position of the door within the parent surface is specified through X,Y coordinates. The size is specified as a height and width (all doors are generally assumed to be rectangular in shape). The details of how the geometry of doors is specified may vary for each energy simulation program.
Units	Data structure: opening
Input Restrictions	As designed

Standard Design	Door geometry in the standard design building is identical to the proposed design.

	Door Construction
Applicability	All exterior doors
Definition	The thermal transmittance of the door, including the frame.
Units	Btu/h·ft^2·°F
Input Restrictions	The construction assembly must be equal to or more efficient than the mandatory U-factor requirements of Section 110.6 of the Standards for new construction. For alterations there are no restrictions..
Standard Design	For new construction, the U-factor required for door construction is defined in Table 140.3-B, C or D of the Standards.

Nonresidential Buildings – U Factor

Non-Swinging Doors	
Climate Zones 1, and 16	U – 0.50
Climate Zones 2 – 15	U – 1.45
Swinging Doors	
Climate Zones 1 – 16	U – 0.70

High-Rise Residential Buildings and Hotel / Motel Guestrooms – U Factor

Non-Swinging Doors	
Climate Zones 1, and 16	U – 0.50
Climate Zones 2 – 15	U – 1.45
Swinging Doors	
Climate Zones 1 – 16	U – 0.70

For alterations, the U-factor in the standard design is either the same standard design as the new construction standard design if the door is replaced, or the equal to the existing door construction, if the door is unaltered. Where applicable, selection shall be based on building type, assembly, and climate zone.

5.5.7 Fenestration

Note that fenestration includes windows, doors that have more than 50% glazed area, and skylights. A skylight is fenestration that has a tilt of less than 60° from horizontal.

Fenestration Name	
Applicability	All fenestration, optional input
Definition	A unique name or code that relates the fenestration to the design documents and a parent surface.
Units	Text: unique

Input Restrictions	No restrictions
Standard Design	Not applicable

Fenestration Type (Vertical Fenestration)

Applicability	All vertical fenestration
Definition	This is a classification of vertical fenestration that determines the thermal performance and solar performance requirement for vertical fenestration.
Units:	List: Fixed, Operable, Curtain Wall, or Glazed Doors
Input Restrictions	As designed
Standard Design	Same as the proposed design

Fenestration Type (Skylights)

Applicability	All skylights
Definition	This is a classification of skylights that determines the thermal performance and solar performance requirement for vertical fenestration.
Units:	List: Glass, curb-mounted, Glass, deck-mounted, or Plastic
Input Restrictions	As designed.
Standard Design	Same as the proposed design

Default Fenestration Type

Applicability	All fenestration that uses default thermal performance factors
Definition	This is a classification of fenestration that determines the thermal performance for fenestration using defaults from Standards Section 110.6, Table 110.6-A. This is used for fenestration without NFRC ratings, or for fenestration for altered buildings that includes window films.
Units:	List: Fixed, Operable, Greenhouse/garden, doors, or Skylight
Input Restrictions	As designed
Standard Design	Not applicable

Default Glazing Type

Applicability	All fenestration that uses default thermal performance factors
Definition	This is a classification of fenestration that determines the thermal performance for fenestration using defaults from Standards Section 110.6, Table 110.6-A. This is used for fenestration without NFRC ratings, or for fenestration for altered buildings that includes window films.
Units:	List: Single Pane, Double Pane, Glass Block
Input Restrictions	As designed, Glass Block is only allowed if the Default Fenestration Type is *Operable* or *Fixed*
Standard Design	Not applicable

Default Framing Type

Applicability All fenestration that uses default thermal performance factors and window films for altered fenestration

Definition This is a classification of fenestration that determines the thermal performance for fenestration using defaults from Standards Section 110.6, Table 110.6-A. This is used for fenestration without NFRC ratings, or for fenestration for altered buildings that includes window films.

Units: List: Metal, Metal with Thermal Break, Nonmetal

Input Restrictions As designed

Standard Design Not applicable

Fenestration Geometry

Applicability All fenestration

Definition Fenestration geometry defines the position and dimensions of the fenestration surface within its parent surface and the identification of the parent surface. The orientation and tilt is inherited from the parent surface. The details of how the coordinate system is implemented may vary between Compliance Software programs.

Display Perimeter. Display perimeter is the length of an exterior wall in a B-2 occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk. The compliance software shall allow the user to specify a value for the length of display perimeter, in feet, for each floor or story of the building. The user entry for Display Perimeter shall have a default value of zero. Note: Any non-zero input for Display Perimeter is an exceptional condition that shall be reported on the PRF-1 exceptional condition list and shall be reported on the ENV forms. The value for Display Perimeter is used as an alternate means of establishing Maximum Wall Fenestration Area in the standard design (§140.3 of the Standards).

The Display Perimeter shall be calculated separately for West facing fenestration, and for non-West facing fenestration.

Floor Number. The compliance software shall also allow the user to specify the Display Perimeter associated with each floor (story) of the building.

Units Data structure: opening

Geometry is defined relative to the parent surface and can include setbacks.

Inputs include:

Geometry of opening (window or skylight), parent surface, display perimeter (optional), percent of roof area exempt from skylight requirements §140.3 of the Standards.

Input Restrictions As designed.

Specification of the fenestration position within its parent surface is required for the following conditions:

1) Exterior shading is modeled from buildings, vegetation, other objects; or

2) If daylighting is modeled within the adjacent space.

Standard Design

The standard design calculates the window wall ratio (WWR) for each orientation and the overall window wall ratio for the building. The window wall ratio is the total fenestration area (including framing) divided by the gross exterior wall area (excluding wall area that is underground). Note that exterior wall area that is below grade, but has exposure to ambient conditions, and any associated fenestration, is included in the WWR calculation.

The standard design vertical fenestration area and horizontal fenestration area for spaces that are specified as computer rooms or data centers (a server process load of 20W/ft2 or higher) shall be zero (0).

For all other buildings, the geometry of the fenestration in the standard design shall be identical to the proposed design with the following exceptions:

Exception 1. Either the whole building window wall ratio or west window wall ratio exceeds 40%.

Exception 2. If display perimeter is entered, the fenestration area exceeds the greater of 40% of the gross wall area (excluding adiabatic walls) and six times the display perimeter.

Exception 1. The fenestration is adjusted based on the following conditions:

Case 1. $WWR_o > 0.40$, $WWR_w \leq 0.40$

In this case, the fenestration area of all windows is reduced by multiplying the fenestration area by the ratio $0.40/WWR_o$. The dimensions of each window are reduced by increasing the sill height so that the window height is modified by the multiplier ($0.40/WWR_o$) so that the same window width is maintained.

Case 2: $WWR_o < 0.40$. $WWR_w > 0.40$

In this case, the fenestration area of all windows on the west orientation is reduced by multiplying the fenestration area by the ratio $0.40/WWR_o$. The dimensions of each window are reduced by multiplying the proposed window dimension by increasing the sill height so that the window height is modified by the multiplier ($0.40/WWR_o$), so that the window width is maintained.

Case 3: $WWR_o > 0.40$. $WWR_w > 0.40$

If both the west window wall ratio and the overall window wall ratio exceed the prescriptive limit of 0.40, the fenestration areas must be reduced by:

1) Adjust the West window area multiplying the west window area by the ratio $0.4/WWR_w$.
2) Calculate the WWR of the north, east and south facades:

   WWR_{nes} = Window $Area_{nes}$ / Gross Wall $Area_{nes}$

3) Adjust the window area of the windows on the north, east and south facades by the following ratio:

   $WindowArea_{N,std} = WindowArea_{N,prop} \times 0.4 / WWR_{nes}$

   $WindowArea_{E,std} = WindowArea_{E,prop} \times 0.4 / WWR_{nes}$

   $WindowArea_{S,std} = WindowArea_{S,prop} \times 0.4 / WWR_{nes}$

4) Adjust each window geometry for the west façade by multiplying the window height by ($0.4/WWR_w$) by adjusting the sill height and by maintaining the same window width.
5) Adjust each window geometry for the north, east and south façade by multiplying the window height by ($0.4/WWR_{nes}$) by adjusting the sill height and by maintaining the same window width.

Exception 2. If the display perimeter is entered and the window area exceeds the prescriptive limit, the window area for the standard design is calculated by multiplying the proposed window area by the following ratio:

$WindowArea_{std}$ = 6 x DisplayPerimeter

The geometry of each window is modified by the following, and by modifying the sill height but not the head height position relative to the floor:

$WindowHeight_{std} = WindowHeight_{prop} \times (WindowArea_{std}/WindowArea_{prop})$

$WindowWidth_{std} = WindowWidth_{prop}$

The following rules apply for calculating geometry of skylights. For the calculation of the standard design skylight area, the gross roof area is defined as the total roof area, including skylights, that is directly over conditioned space.

The skylight area of the standard design is set to:

(1) For buildings without atria or with atria having a height less than 55 feet over conditioned space, the smaller of the proposed skylight area and 5% of the gross roof area that is over conditioned space

(2) For buildings with atria at a height of 55ft or greater over conditioned spaces, the smaller of the proposed skylight area and 10% of the gross roof area that is over conditioned space

(3) For buildings with atria or other roof area directly over unconditioned spaces, the smaller of the proposed skylight area or 5% of the roof area excluding the atria area and excluding any adiabatic walls, if present in the modeled building. The skylight area of the atria or roof area directly over unconditioned space is not included in the skylight area limit in this case.

The skylight area for atria over unconditioned space is not included in determining the skylight to roof ratio (SRR) for the building.

Depending on the following condition, adjustments to the SRR as described below shall be made.

i. For open spaces other than auditoriums, churches, movie theaters, museums and refrigerated warehouses, for buildings in climate zones 2 through 15, and when spaces have ceiling heights greater than 15 ft and floor areas greater than 5000 ft^2, - building Floor area x 0.75 = Total primary daylit area+ Total skylit daylit area. See 5.4.5 for detail description on Primary Daylit area and Skylit Daylit area.

ii. If the above condition is met and SRR ≤ 0.05, no adjustments are needed.

iii. If the condition is met and SRR > 0.05, skylight dimensions = Existing Dimension x [1- √ (0.05/SRR of Proposed Building)]

iv. If the condition is not met triggering the need for additional skylights, the baseline case shall be modeled with new skylights irrespective of the skylight location of the proposed case. The new skylights shall be distributed uniformly such that there is no overlapping of primary daylit areas from skylights or sidelights. The dimension of the new skylights shall be the same as the proposed design if calculated new SRR ≤ 0.05. If SRR > 0.05, skylight dimensions = Existing Dimension x [1- √ (0.05/SRR of Proposed Building)].

Note that the adjustments to SRR are done after adjustments to WWR, if any are completed.

Standard Design, Existing Buildings, Additions and Alterations

For alterations of existing vertical fenestration or skylights, where no fenestration area is added, the Fenestration Geometry of the standard design shall be the same as the proposed for the existing building.

For additions of vertical fenestration or skylights, where the additional fenestration causes the fenestration area to exceed the limit of 40% window to wall ratio (WWR) for the building, 40% WWR for the west orientation of the building, 5% skylight to roof ratio (SRR) for existing buildings without atria 55 feet or higher, or 10% SRR for existing buildings with atria 55 feet or higher, the fenestration geometry for the standard design shall be adjusted from the proposed design according to the rules set forth under the *Standard Design* rules.

For additions of vertical fenestration and/or skylights that do not cause the fenestration area to exceed any of these limits, the fenestration geometry of the standard design shall be the same as the proposed design.

Skylight Requirement Exception Fraction

Applicability All buildings with interior ceiling heights greater than 15 feet

Definition This is the fraction of floor area that is exempt from the minimum skylight area requirement for spaces with high ceilings.

Identifying areas subject to §140.3 of the Standards

When a proposed space has ceiling heights greater than 15 feet, with exterior surfaces having a tilt angle less than 60 degrees (roofs) and no more than 3 stories above grade, the user shall enter the fraction of the modeled space that is exempt from requirements of §140.3 of the Standards. If the proposed design has skylights, the user shall also indicate the area of the proposed design daylight area under skylights in this space. When the user enters a value greater than 0 %for the fraction of the space area exempt to §140.3 of the Standards, the compliance software shall require that the user indicate at least one of the following exceptions:

1. The building is not located in climate zone 1 or climate zone 16.
2. Designed general lighting is less than 0.5 W/ft^2
3. Existing walls on plans result in enclosed spaces less than 5,000 ft^2
4. Future walls or ceilings on plans result in enclosed spaces less than 5,000 ft^2 or ceiling heights less than 15 feet.
5. Plans or documents show that space is an auditorium, religious building of worship, movie theater, museum, or refrigerated warehouses.

Units: List: Four exceptions listed above (specified if fraction > 0)

Input Restrictions No restrictions, other than that the vertical fenestration type must agree with the type specified on the construction documents or the as-built drawings.

Standard Design Same as the proposed design

Standard Design, Existing Buildings Not applicable

Fenestration Construction

Applicability All fenestration

Definition A collection of values that together describe the performance of a fenestration system. The values that are used to specify the criteria are U-factor, SHGC and VT. U-factor and SHGC inputs are whole-window values.

Units Data structure: shall include at a minimum the following properties as specified by NFRC ratings:

U-factor: whole window U-factor

SHGC: whole window solar heat gain coefficient

VT: visible transmittance

Input Restrictions

For new construction, performance information for fenestration shall be obtained from NFRC test results or shall be developed from procedures outlined in section 110.6 of the Standards, as specified below. Values entered shall be consistent with the specifications and the construction documents.

For manufactured products:

- U-factor, SHGC and VT shall be equivalent to NFRC rated values.
- -For products not rated by NFRC, U-factor, SHGC and VT shall be determined from CEC default tables (110.6 A and B).

For site built products:

- U-factor, SHGC and VT shall be equivalent to NFRC rated values.
- For products not rated by NFRC, U-factor, SHGC and VT shall:
- be determined from CEC default tables (110.6 A and B) when total site built fenestration > 1000 ft2
- be determined from methods outlined in NA-6 when total site built fenestration <=1000 ft2

For field fabricated products:

- U-factor, SHGC and VT shall be determined from CEC default tables (110.6 A and B)

For buildings with fenestration area that meets requirements for use of center-of-glass U-factor and SHGC, the fenestration overall U-factor, SHGC and VT shall be determined by the following equations from the Reference Appendix NA6:

$U_T = C_1 + (C_2 \cdot U_c)$

$SHGC_T = 0.08 + (0.86 \cdot SHGC_c)$

$VT_T = VT_F \cdot VT_C$

Where,

U_T = U-factor is the Total Performance of the fenestration including glass and frame

C_1 = Coefficient selected from Table NA6-5 in Reference Appendix NA6

C_2 = Coefficient selected from Table NA6-5 in Reference Appendix NA6

U_C = Center of glass U-factor calculated in accordance with NFRC 100 Section 4.5.3.1

$SHGC_T$ = SHGC Is

$SHGC_C$ = Center of glass SHGC calculated in accordance with NFRC 200 Section 4.5.1.1

VT_T = Is the Total Performance of the fenestration including glass and frame

VT_F = 0.53 for projecting windows, such as casement and awning windows

VT_F = 0.67 for operable or sliding windows

VT_F = 0.77 for fixed or non-operable windows

VT_F = 0.88 for curtain wall/storefront, Site-built and manufactured non-curb mounted skylights

VT_F = 1.0 for Curb Mounted manufactured Skylights

VT_C = Center of glass VT is calculated in accordance with NFRC 200 Section 4.5.1.1 or NFRC 202 for Translucent Products or NFRC 203 for Tubular Daylighting Devices and Hybrid Tubular Daylighting Devices or ASTM E972

For skylights, the default values shall be the alternate default U-factor and SHGC using default calculations specified above and in Reference Appendix NA6 or the U-factor and SHGC listed in Table 110.6-A and Table 110.6-B in the Standards.

For alterations of existing fenestration using window films, the thermal performance for solar heat gain coefficient shall be calculated from two user inputs:

1) Default Glazing Reference: unique identifier for the glazing without film, that determines the CEC default value (column 3 in table below) and the SHGC ratio multiplier (column 4), and
2) NFRC window film SHGC: the solar heat gain coefficient multiplier for the window film, from NFRC ratings.

The adjusted SHGC for the glazing with the window film is:

SHGCadj = DefaultSHGCValue x SHGCRatio x NFRCfilm

Where

DefaultSHGCValue = the CEC default value from 110.6, given in column 3 in the table below

SHGCRatio = multiplier based on the default glazing reference, given in column 4 in the table below

NFRCfilm – the NFRC SHGC rating of the window film

1	2	3		4		5		6
Operator Type	**Default Glazing Reference**	**CEC Default SHGC Value Table 110.6-B X**		**SHGC Ratio X_y**		**NFRC Window Film SHGC[1,2,3] Z**		**New Adjusted Total Value T**
Residential or Commercial								
Fixed	3 mm (1/8in.) clear (Single Pane)	0.83	x	1.1528	x		=	
Fixed	3 mm (1/8in.) clear	0.73	x	1.1406	x		=	

	3 mm (1/8in.) clear (Double Pane - Clear)							

1	2	3		4		5		6
Operator Type	**Default Glazing Reference**	**CEC Default SHGC Value Table 110.6-B X**		**SHGC Ratio X_y**		**NFRC Window Film SHGC[1,2,3] Z**		**New Adjusted Total Value T**
Residential or Commercial								
Fixed	3 mm (1/8in.) clear (Single Pane)	0.83	x	1.1528	x		=	
Fixed	3 mm (1/8in.) clear 3 mm (1/8in.) clear (Double Pane - Clear)	0.73	x	1.1406	x		=	

Standard Design For new construction, the requirements for vertical fenestration U factor, Solar Heat Gain Coefficient, and Visible light transmission by window type and framing type are specified in Table 140.3-B, C or D of the Standards. For plastic skylights, a SHGC of 0.50 shall be assumed.

Standard Design, Existing Buildings The U-factor, SHGC and VT in the standard design shall be modeled as design if unchanged, as the values stated in Table 141.0-A of the Standards when the existing window area is unchanged (different than the new construction performance requirement), or Table 140.3-B, C or D of the Standards for all other cases.

The standard design does not include window films.

External Shading Devices

Applicability All fenestration

Definition Devices or building features that are documented in the construction documents and shade the glazing, such as overhangs, fins, shading screens, and setbacks of windows from the exterior face of the wall. Objects that shade the building but are not part of the building and parts of the building that cause the building to shade itself are also modeled, but are not a part of this building descriptor. See *Shading of the Building Site*. The Title 24 compliance software shall be capable of modeling vertical fins and overhangs. Recessed windows may also be modeled with side fins and overhangs.

Units Data structure: opening shade

Input Restrictions No restrictions other than that the inputs must match the construction documents

Standard Design The standard design building is modeled without external shading devices.

Internal Shading Devices

Applicability	All fenestration
Definition	Curtains, blinds, louvers, or other devices that are applied on the room side of the glazing material. Glazing systems that use blinds between the glazing layers are also considered internal shading devices. Glass coatings, components or treatments of the glazing materials are addressed through the *Fenestration Construction* building descriptor.
Units	Data structure: Indicates the type of control, or blind schedule if applicable
Input Restrictions	Internal shading shall not be modeled in the proposed design, unless it is automatically controlled, based on input from an astronomical timeclock, an exterior pyronometer, or other sensors. The control algorithm shall be documented on the construction documents. Interior shades without automatic controls shall not be modeled Interior shades shall only be modeled when automatic controls are present.
Standard Design	The baseline building shall be modeled without interior shades. None (not applicable)

SHGC Dim Fraction

Applicability	Fenestration with switchable glazing
Definition	For switchable glazing, this is the fraction of the solar heat gain coefficient when darkened to the solar heat gain coefficient during normal operation. This can be applied when the solar heat gain exceeds a specified threshold, or controlled by an electrical signal.
Units	Unitless
Input Restrictions	Internal shading shall not be modeled in the proposed design, unless it is automatically controlled, based on input from an astronomical timeclock, an exterior pyronometer, or other sensors. The control algorithm shall be documented on the construction documents. Interior shades without automatic controls shall not be modeled
Standard Design	Not Applicable.

VT Dim Fraction

Applicability	Fenestration with switchable glazing
Definition	For switchable glazing, this is the fraction of the visible transmittance when darkened to the visible transmittance during normal operation. This can be applied when the solar heat gain exceeds a specified threshold, or controlled by an electrical signal.
Units	Unitless
Input Restrictions	Internal shading shall not be modeled in the proposed design, unless it is automatically controlled, based on input from an astronomical timeclock, an exterior pyronometer, or other sensors. The control algorithm shall be documented on the construction documents. Interior shades without automatic controls shall not be modeled
Standard Design	

Switchable Solar Heat Gain Threshold

Applicability	Fenestration with automatically controlled switchable glazing.
Definition	For switchable glazing, this is the solar heat gain threshold above which the dynamic

glazing is active (darkened). When the solar heat gain drops below this threshold, the glazing is switched back to being inactive (clearest setting). Indoor and outdoor air temperatures are the setpoints required for controlling the Switchable Solar Heat Gain Threshold. A flag may be used to indicate that this control is not used. During both occupied and unoccupied hours, the recommendation for the control of solar heat gain coefficient (SHGC) is to have the switchable glazing set to inactive (clearest setting) when the outdoor air temperature is below the heating setpoint, and active (darkened) when the outdoor air temperature is equal to or above the heating setpoint. The heating setpoint value shall be based on building type from ACM Appendix 5.4B.

Units Incident solar threshold (Btu/h-ft2)

Input Restrictions As designed. During both occupied and unoccupied hours, the recommendation for the control of solar heat gain coefficient (SHGC) is to have the switchable glazing set to inactive (clearest setting) when the outdoor air temperature is below the heating setpoint, and active (darkened) when the outdoor air temperature is equal to or above the heating setpoint. The heating setpoint value shall be based on building type from ACM Appendix 5.4B.

Standard Design

Switchable Space Temperature Threshold

Applicability Fenestration with automatically controlled switchable glazing.

Definition For switchable glazing, this is the space temperature above which the dynamic glazing is active (darkened). When the solar heat gain drops below this threshold, the glazing is switched back to being inactive (clearest setting). Indoor and outdoor air temperatures are the setpoints required for controlling the Switchable Solar Heat Gain Threshold. This may be used in combination with the solar heat gain and illuminance thresholds for control. A flag may be used to indicate that this control is not used. During both occupied and unoccupied hours, the recommendation for the control of solar heat gain coefficient (SHGC) is to have the switchable glazing set to inactive (clearest setting) when the outdoor air temperature is below the heating setpoint, and active (darkened) when the outdoor air temperature is equal to or above the heating setpoint. The heating setpoint value shall be based on building type from ACM Appendix 5.4B.

Units °F

Input Restrictions The space heating and cooling setpoints are prescribed from Appendix 5.4B. A flag may be used to indicate that this control is not used. During both occupied and unoccupied hours, the recommendation for the control of solar heat gain coefficient (SHGC) is to have the switchable glazing set to inactive (clearest setting) when the outdoor air temperature is below the heating setpoint, and active (darkened) when the outdoor air temperature is equal to or above the heating setpoint. The heating setpoint value shall be based on building type from ACM Appendix 5.4B.

Standard Design

Switchable Illuminance Threshold

Applicability Fenestration with automatically controlled switchable glazing.

Definition For switchable glazing, this is the illuminance threshold above which the dynamic glazing is regulated between active (darkened) and inactive (clearest setting). With a single illuminance setpoint the switchable glazing will adjust between the clearest and darkest setting to allow the desired illuminance level. A flag may be used to indicate that this control is not used. During both occupied and unoccupied hours, the recommendation for the control of solar heat gain coefficient (SHGC) is to have the switchable glazing set to inactive (clearest setting) when the outdoor air temperature is below the heating setpoint, and active (darkened) when the outdoor air temperature is

	equal to or above the heating setpoint. The heating setpoint value shall be based on building type from ACM Appendix 5.4B.
Units	Lux
Input Restrictions	As designed During occupied hours, the recommendation for the illuminance threshold setpoint is to match a point within the recommended illumination levels, based on space type, from Appendix 5.4A. Values below this recommended range may require special documentation. During unoccupied hours, the recommendation is to have the Switchable Solar Heat Gain Threshold descriptor in control of the switchable glass. If this descriptor is used in conjunction with the Switchable Solar Heat Gain Threshold descriptor, glare will need to be an additional parameter to control which threshold is used during occupied hours.
Standard Design	Not Applicable.

Switchable Glazing Schedule	
Applicability	Fenestration with switchable glazing controlled by an electrical signal
Definition	For switchable glazing, this is an hourly schedule for the when the switchable glazing is darkened, when controlled by an electrical signal.
Units	Boolean: 1 if switchable glazing is active (darkened); 0 if not active
Input Restrictions	0 or 1 for schedule values.
Standard Design	Not applicable.

5.5.8 Below Grade Walls

Below Grade Wall Name	
Applicability	All projects, optional input
Definition	A unique name that keys the below grade wall to the construction documents
Units:	Text: unique
Input Restrictions	None
Standard Design	Not applicable

Below Grade Wall Geometry	
Applicability	All projects
Definition	A geometric construct that describes the dimensions and placement of walls located below grade. Below grade walls have soil or crushed rock on one side and interior space on the other side. Some simulation models take the depth below grade into account when estimating heat transfer, so the geometry may include height and width.
Units	Data structure: below grade wall geometry

Input Restrictions As designed

Standard Design The geometry of below grade walls in the standard design building is identical to the below grade walls in the proposed design.

Below Grade Wall Construction

Applicability All projects, required input

Definition A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for below grade wall construction type.

Units Data structure: construction assembly

The construction can be described as a C-factor which is similar to a U-factor, except that the outside air film is excluded, or the construction can be represented as a series of layers, like exterior constructions.

Input Restrictions The construction assembly, defined by a series of layers, must be equal to or more efficient than the mandatory R-value and C-factor requirements of Section 120.7 of the Standards for new construction, and Section 141.0 of the Standards for alterations. Note that these requirements only apply when the slab floor connected to the below grade wall is heated.

For new construction, the inputs shall be in agreement with the construction documents. Values for the C-factor shall be taken from Table 4.3.5, 4.3.6 or 4.3.7 of Reference Appendix JA4.

For alterations there are no restrictions.

Standard Design For new construction, See Table 15. The standard design building shall use default values for C-factor. The height shall be the same as specified in the proposed design.

For ***below grade*** walls, the standard design construction shall include the following layers:

Table 15 – Standard Design Building Below-Grade Wall Construction Assemblies

Construction	Layer	Thickness (inch)	Conductivity (Btu/h ft F)	Density (lb/ft²)	Specific Heat (Btu/lb F)	R-value (ft²·°F·h/Btu)	C-factor (Btu/ft²·°F·h)
NR	115 lb/ft3 CMU, solid grout	8	0.45	115	0.20	0.87	1.140
R-7.5 c.i.	115 lb/ft3 CMU, solid grout	8	0.45	115	0.20	0.87	
	R-10 continuous insulation	1.8	0.02	1.8	0.29	7.50	
	Total assembly					8.37	0.119
R-10 c.i.	115 lb/ft3 CMU, solid grout	8	0.45	115	0.20	0.87	
	R-10 continuous insulation	2.4	0.02	1.8	0.29	10.00	
	Total assembly					10.87	0.092
R-12.5 c.i.	115 lb/ft3 CMU, solid grout	8	0.45	115	0.20	0.87	
	R-10 continuous insulation	3.0	0.02	1.8	0.29	12.50	
	Total assembly					13.37	0.075

For alterations, the C-factor in the standard design shall be modeled as the more efficient of either the existing conditions, or the values stated above for new construction standard design.

For *below grade* walls, the alteration standard design assembly shall include the appropriate existing layers.

5.5.9 Slab Floors in Contact with Ground

These building descriptors apply to slab-on-grade or below-grade floors that are in direct contact with the ground.

Slab Floor Name	
Applicability	All slab floors, optional
Definition	A unique name or code that relates the exposed floor to the construction documents.
Units	Text: unique
Input Restrictions	None
Standard Design	Not applicable

Slab Floor Type	
Applicability	All slab floors, required
Definition	One of two classes for floors in contact with ground. The classes are: 1) Heated slab-on-grade floors, 2) Unheated slab-on-grade floors 3) Heated below-grade floors 4) Unheated below-grade floors. Heated slab-on-grade floors include all floors that are heated directly in order to provide heating to the space. Unheated slab-on-grade floors are all other floors in contact with ground.
Units	List: restricted to the four selections listed above
Input Restrictions	None
Standard Design	The slab for type is unheated (either *unheated slab-on-grade* for slab-on-grade floors or *unheated below-grade* for below grade floors.

Slab Floor Geometry	
Applicability	All slab floors, required
Definition	A geometric construct representing a slab floor in contact with the earth. The geometric representation can vary depending on how the energy simulation software models slabs-on-grade. Some models require that only the perimeter of the slab be entered. Other models divide the slab into a perimeter band within 2 ft of the edge and the interior portion or core area, such that the perimeter area and the core area sum to the total area of the slab.
Units:	Data structure: as appropriate for the simulation tool This may include: Area, Perimeter Exposed
Input Restrictions	No restrictions
Standard Design	The geometry of the slab floor in the standard design building is identical to the slab floor in the proposed design.

Slab Floor Construction	
Applicability	

	All slab floors, required input
Definition	A specification containing a series of layers that result in a construction assembly for the proposed design. The first layer in the series represents the outside (or exterior) layer and the last layer represents the inside (or interior) layer. See the building descriptors above for slab floor construction type. A description of how the slab is insulated (or not). How the construction is described will depend on the energy simulation model. The construction can be represented by an F-factor that represents the entire construction (floor and insulation). Simple models may include just an F-factor, representing an instantaneous heat loss/gain to outside air. The F-factor could be related to the configuration of insulation in the proposed design. Other slab loss models may require that the surface area of the slab floor be divided between the perimeter and the interior. The insulation conditions then define heat transfer between both outside air and ground temperature. The insulation condition for slabs includes the R-value of the insulation and the distance it extends into the earth at the slab edge and how far it extends underneath the slab.
Units	List ***F-factor from Reference Appendix JA4;*** *this is one selection from list 1 and one selection from list 2. Note that some combinations from list 1 and list3 are not allowed – see Reference Appendix JA4 Table 4.4.8 and Table 4.4.7 for details.* List 1: None, 12 in horizontal, 24 in horizontal, 36 in horizontal, 48 in horizontal, 12 in vertical, 24 in vertical, 36 in vertical, 48 in vertical, Fully insulated slab List 2: R-0, R-5, R-7.5, R-10, R-15, R-20, R-25, R-30, R-35, R-40, R-45, R-50, R-55
Input Restrictions	The construction assembly, defined by an F-factor, must be equal to or more efficient than the mandatory F-factor requirements of Section 120.7 of the Standards for new construction, and Section 141.0 of the Standards for alterations. For new construction, F-factors shall be taken from Table 4.4.8 of Reference Appendix JA4 for heated slab floors and Table 4.4.7 for unheated slab floors. For all methods, inputs shall be consistent with the construction documents. For heated slab floors, the F-factor shall be determined by the mandatory R-value and installation requirements in Section 110.8 of the Standards, and then that information is used in Table 4.4.8 of Reference Appendix JA4 to determine the required F-factor. For alterations the same requirements apply.
Standard Design	Slab loss shall be modeled with the simple method (F-factor). The standard design construction shall include the following layers: Layer 1 Concrete 140lb/ft3 – 6 in. R - 0.44 The Standard Design shall include No insulation, equivalent to an F-factor of 0.73. For alterations, the F-factor in the standard design shall be modeled as the more efficient of either the existing conditions, or the values stated above for new construction standard design.

5.5.10 Heat Transfer between Thermal zones

Partition Name	
Applicability	All partitions, optional
Definition	

	A unique name or code that relates the partition to the construction documents.
Units	Text: unique
Input Restrictions	The text should provide a key to the construction documents.
Standard Design	Not applicable

Partition Geometry

Applicability	All partitions
Definition	A geometric construct that defines the position and size of partitions that separate one thermal zone from another. The construct shall identify the thermal zones on each side of the partition. Since solar gains are not generally significant for interior partitions, the geometry of partitions is sometimes specified as just an area along with identification of the thermal zones on each side.
Units	Data structure: surface with additional information identifying the two thermal zones that the partition separates.
Input Restrictions	No restrictions other than agreement with the construction documents
Standard Design	The geometry of partitions in the standard design building shall be identical to the proposed design.

Partition Construction

Applicability	All partitions
Definition	A description of the construction assembly for the partition
Units	Data structure: construction assembly
Input Restrictions	As designed
Standard Design	Partitions in the baseline building shall be steel framed walls with 5/8 in. gypsum board on each side. For walls, partitions in the standard design building shall be steel framed walls with 5/8 in. gypsum board on each side. For interior floors and ceilings, baseline construction shall be 5/8 in. gypsum board, an air space of 4” or more, and 5/8” gypsum board.

Demising Partition Construction

Applicability	All demising walls and demising partitions (ceilings, floors) that separate conditioned spaces from unconditioned spaces
Definition	A description of the construction assembly for the partition
Units	Data structure: construction assembly
Input Restrictions	As designed
Standard Design	Partitions in the baseline building shall be steel framed walls with 5/8 in. gypsum board on each side. For walls, partitions in the standard design building shall be steel framed walls with 5/8 in. gypsum board on each side and R-13 fiberglass batt insulation between the studs Demising ceiling partitions, separating conditioned space from unconditioned space and attics, shall be insulated to the same levels as exterior roofs in section 5.5.3. Demising floor partitions shall be insulated to the same levels as exterior floors in section 5.5.5.

5.5.11 Simplified Geometry Simulation Option

The compliance software may have an option to model a building with simplified (two-dimensional geometry). This is an optional capability as an alternative to modeling the three-dimensional geometry of a building. If the compliance software only provides a two-dimensional building model, the following features cannot be modeled:

- Daylighting controls and dimming
- Exterior shading or self-shading

All mandatory and prescriptive daylight controls must be present when submitting a compliance project using software that only models a building with two-dimensional geometry.

The compliance software must pass all reference method tests corresponding to two-dimensional geometry to meet certification requirements as compliance software. Consult Appendix 3B of the ACM Reference Manual for additional information. The software must pass the ruleset implementation tests, and for the sensitivity tests that verify simulation accuracy, there are 2D tests specified for building envelope, but for other building components (lighting, HVAC), the software is compared against the results of the reference method, which uses a three-dimensional geometry model.

The compliance software must have sufficient information to specify each exterior surface when modeling a building with two-dimensional geometry. At a minimum, building surface azimuth, elevation, area are required and the tilt, azimuth and area is specified for roof components. The model must use only vertical walls for the analysis. The model follows all other ACM requirements for space and zone definitions, lighting and HVAC specifications, and follows the same rules for the standard design and proposed design constraints.

The model also requires the following explicit inputs from the user:

- Total Building Story Count – the total number of stories
- Total Above Grade Stories – the total number of stories above grade, used in determination of high-rise residential classification

5.6 HVAC Zone Level Systems

This group of building descriptors relate to HVAC systems at the zone level. There is not a one-to-one relationship between HVAC components in the proposed design and the Standard Design since the Standard Design system is determined from building type, size, and heating source. The applicability of each building descriptor for each of the 11 Standard Design systems is indicated in tables under the building descriptor Standard Design rules. Additions and Alterations should follow the same requirements stated for new construction Proposed Designs and new construction Standard Designs; unless otherwise noted in the descriptor.

5.6.1 Space Temperature Control

Space Thermostat Throttling Range

Applicability	All thermal zones
Definition	The number of degrees that the room temperature must change to cause the HVAC system to go from no heating or cooling (i.e., space temperatures floating) to full heating or cooling.

Units	Degrees Fahrenheit (°F)
Input Restrictions	The prescribed value is 2°F. (This is equivalent to a +/- 1F temperature tolerance around the heating and cooling setpoint.) No input is needed and the prescribed value may not be overridden.
Standard Design	Same as the proposed design

Space Temperature Schedule

Applicability	All thermal zones
Definition	An hourly space thermostat schedule
Units	Data structure: temperature schedule
Input Restrictions	Prescribed. The Schedule Group is specified for the given Space Type in Appendix 5.4A, and the schedule values are specified in Appendix 5.4B.
Standard Design	Schedules in the Standard Design shall be identical to the proposed design.

5.6.2 Terminal Device Data

Terminal Type

Applicability All thermal zones

Definition A terminal unit includes any device serving a zone (or group of zones collected in a thermal zone) that has the ability to reheat or recool in response to the zone thermostat. This includes:

- None (the case for single zone units)
- VAV box
- Series Fan-Powered VAV box
- Parallel Fan-Powered VAV box
- Induction-type VAV box
- Dual-duct mixing box (constant volume and VAV)
- Two and three duct mixing dampers (multi-zone systems)
- Reheat coil (constant volume systems)
- Perimeter induction units

Units List (see above)

Input Restrictions As designed

Standard Design Table 16 specifies the HVAC terminal device for each of the Standard Design systems. See **Error! Reference source not found.** for a summary of the HVAC mapping.

Table 16 – Standard Design HVAC Terminal Devices

Standard Design System	Terminal Type
System 1 – PTAC	None
System 2 – FPFC	None
System 3 – PSZ-AC	None
System 5 – Packaged VAV with Reheat	VAV Box
System 6 – VAV with Reheat	VAV Box
System 7 – SZVAV	None
System 9 – Heating and Ventilation	None
System 10 – CRAH	None
System 11 – CRAC	None
System 12 – LAB	None
System 13 – Kitchen	None

5.6.3 Terminal Heating

This group of building descriptors applies to proposed design systems that have reheat coils at the zone level. The building descriptors are applicable for Standard Design systems 5 and 6.

Terminal Heat Type

Applicability Systems that have reheat coils at the zone level

Definition The heating source for the terminal unit. This includes:

- Electric resistance
- Gas furnace
- Oil furnace
- Hot water
- Steam

Units List (see above)

Input Restrictions As designed.

Standard Design Table 17 shows the terminal heat type for each Standard Design system.

Table 17 – Baseline Building Terminal Heat Type

Baseline building System	Terminal Heat Type
System 1 – PTAC	None
System 2 – PTHP	None
System 3 – PSZ-AC	None
System 4 – PSZ-HP	None
System 5 – Packaged VAV with Reheat	Hot Water
System 6– VAV with Reheat	Hot Water
System 7 – SZVAV	None
System 8 – SZVAV HP	None
System 9 – Heating and Ventilation	None
System 10 – CRAH Unit	None
System 11 – CRAC Unit	None
System 12 – LAB	None
System 13 – Kitchen	None

Terminal Heat Capacity

Applicability Systems that have reheat coils at the zone level

Definition The heating capacity of the terminal heating source

Units Btu/h

Input Restrictions As designed. However, if the unmet load hours exceed 150, the energy analyst and design team may have to increase the size of the equipment so that the unmet load hours are less than 150. See Figure 10 Figure 2.

Standard Design The software shall automatically size the terminal heating capacity to be 25% greater than the design loads. See Figure 2.

Reheat Delta T

Applicability Systems that have reheat coils at the zone level

Definition This is an alternate method to enter the terminal heat capacity. It can be calculated as follows:

(3)

$$\Delta T_{reheat} = T_{reheat} - T_{cool\_supply}$$
$$\Delta T_{reheat} = Q_{coil} / (1.1 * CFM)$$

Where:

ΔT_{reheat}	heat rise across the terminal unit heating coil (°F)
T_{reheat}	heating air temperature at design (°F)
T_{cool_supply}	supply air temperature at the heating coil (°F)
Q_{coil}	heating coil load (Btu/h)
CFM	airflow (cfm)

Units Degrees Fahrenheit (°F)

Input Restrictions As designed, but may need to be increased if zone unmet load hours are greater than

	150.
Standard Design	Method not used for standard design. (The temperature difference shall be no more than 40°F.) See Heat Capacity above.

5.6.4 Baseboard Heat

Baseboard Capacity	
Applicability	All thermal zones
Definition	The total heating capacity of the baseboard unit(s)
Units	Btu/h
Input Restrictions	As designed
Standard Design	Not applicable to the standard design

Baseboard Heat Control	
Applicability	All thermal zones
Definition	Defines the control scheme of base board heating as either: • Controlled by a space thermostat
Units	List (see above)
Input Restrictions	Controlled by space thermostat is the only type allowed if baseboard heating is used.
Standard Design	Not applicable for the standard design

5.6.5 Zone Level Air Flow

5.6.5.1 VAV Air Flow

This group of building descriptors applies to proposed design systems that vary the volume of air at the zone level. The building descriptors are applicable for standard design systems 5 and 6.

Design Airflow	
Applicability	Systems that vary the volume of air at the zone level
Definition	The air delivery rate at design conditions
Units	cfm
Input Restrictions	As designed. If the unmet load hours in the proposed design are greater than 150, the user may have to modify the Design Airflow value manually.
Standard Design	For systems 5 and 6, the software shall automatically size the system airflow to meet both: (a) the standard design peak cooling load based on a supply-air-to-room-air temperature difference of 20°F for exterior zones or 15°F for interior zones, the required ventilation air from Table 120.1-A of the Standard, or makeup air; whichever is greater and (b) the standard design peak heating load based on 50% zone flow and 95°F supply air temperature.

An exterior zone is defined as a type of thermal zone that has any exterior walls, and that has a non-zero amount of vertical fenestration (windows). Any zone that does not meet the definition of an exterior zone is an interior zone.

For kitchen MAU systems, the design airflow is the greater of the airflow required to meet the design cooling loads and the total exhaust CFM.

Terminal Minimum Stop

Applicability Systems that vary the volume of air at the zone level

Definition The minimum airflow that will be delivered by a terminal unit before reheating occurs

Units Unitless fraction of airflow (cfm) or specific airflow (cfm/ft²)

Input Restrictions This input must be greater than or equal to the outside air ventilation rate.

Standard Design For systems 5 and 6 set the minimum airflow to be the greater of 20% of the peak supply air volume to the zone or the minimum outside air ventilation rate.

For laboratories, the minimum airflow fraction shall be fixed at a value equivalent to 6 ACH.

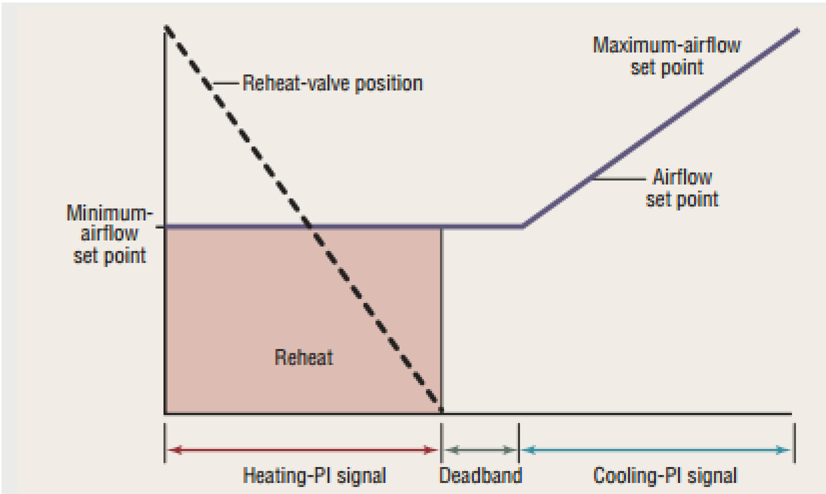
Terminal Heating Control Type

Applicability VAV boxes with reheat

Definition The control strategy for the heating mode.

Single Maximum

In the single maximum control mode, the airflow is set to a minimum constant value in both the deadband and heating mode. This airflow can vary but is typically 30 to 50 percent of maximum. This control mode typically has a higher minimum airflow than the minimum used in the dual maximum below, resulting in more frequent reheat.



Single Maximum VAV Box Control

Courtesy: Taylor Engineering

Dual Maximum: raises the SAT as the first stage of heating, and increases the airflow to the zone as the second stage of heating.

1. The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint no larger than 95ºF while the airflow is maintained at the dead band flow rate.

2. The second stage of heating consists of modulating the airflow rate from the dead band flow rate up to the heating maximum flow rate (50% of design flow rate).

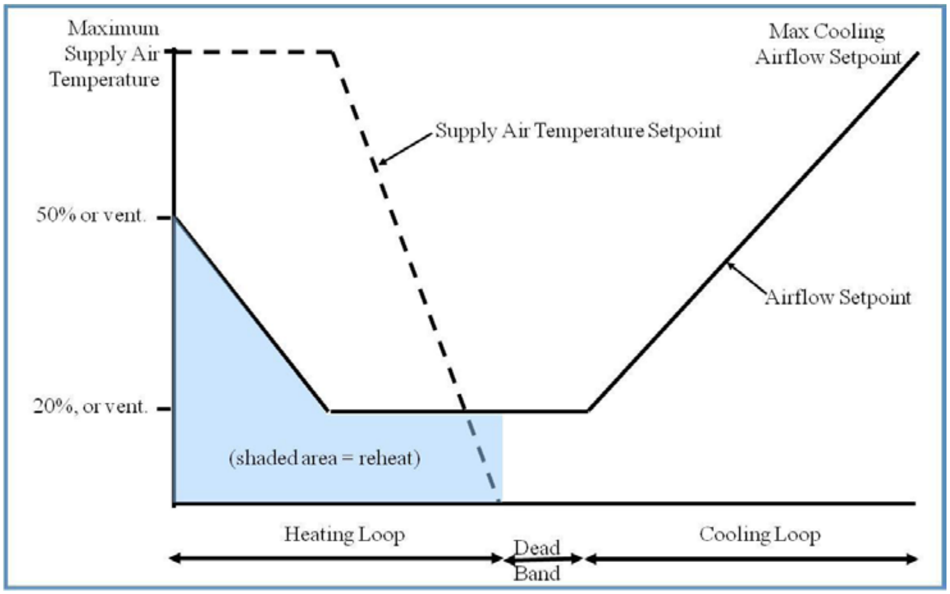


Figure 9 – Dual Maximum Control Sequence

Units	List: Single Maximum Dual Maximum
Input Restrictions	Fixed at Single Maximum if Control System Type is not *DDC Control to the Zone Level*
Standard Design	Dual Maximum

5.6.5.2 Fan Powered Boxes

Fan Powered Box Type

Applicability	thermal zones that have fan powered boxes
Definition	Defines the type of fan-powered induction box. This is either: • Series; or • Parallel
Units	List (see above)
Input Restrictions	As designed
Standard Design	Not applicable

Fan Power

Applicability

	thermal zones that have fan powered boxes
Definition	The rated power input of the fan in a fan-powered box.
Units	W or W/cfm
Input Restrictions	As designed
Standard Design	Not applicable

Fan Powered Box Induced Air Zone

Applicability	thermal zones that have fan powered boxes
Definition	Zone from which a series or parallel fan-powered box draws its air
Units	List (of zones)
Input Restrictions	As designed
Standard Design	Not applicable

Parallel PIU Induction Ratio

Applicability	thermal zones that have fan powered boxes
Definition	The ratio of induction-side airflow of a fan-powered box at design heating conditions to the primary airflow
Units	Ratio
Input Restrictions	As designed
Standard Design	Not applicable

Parallel Fan Box Thermostat Setpoint

Applicability	thermal zones that have parallel fan powered boxes
Definition	The temperature difference above the heating setpoint at which the parallel fan is turned on
Units	Degrees Fahrenheit (°F)
Input Restrictions	2°F above the heating setpoint schedule
Standard Design	Not applicable

5.6.5.3 Zone Exhaust

This group of building descriptors describes the rate of exhaust and the schedule or control for this exhaust. An exhaust system can serve one thermal zone or multiple thermal zones. Energy is summed for the exhaust system level, not the thermal zone level.

This section also contains unique inputs for kitchen exhaust systems that must meet requirements of section 140.9 of the Standards.

Kitchen Exhaust Hood Length

Applicability	Exhaust fans in spaces of type Kitchen, Commercial Food Preparation
Definition	The exhaust hood length
	ft
Input Restrictions	

Units

As designed

Standard Design Same as the proposed design

Kitchen Exhaust Hood Style

Applicability	Exhaust fans in spaces of type Kitchen, Commercial Food Preparation
Definition	The hood style as defined in Table 140.9-A of the Standards
Units	List: Wall-mounted canopy, Single Island, Double Island, Eyebrow, Backshelf/Passover
Input Restrictions	As designed
Standard Design	Same as the proposed design

Kitchen Exhaust Hood Cooking Duty

Applicability	Exhaust fans in spaces of type Kitchen, Commercial Food Preparation
Definition	The hood cooking duty as defined in Table140.9-A of the Standards
Units	List: Light Duty, Medium Duty, Heavy Duty, Extra Heavy Duty
Input Restrictions	As designed
Standard Design	Same as the proposed design

Exhaust Fan Name

Applicability	All thermal zones
Definition	A reference to an exhaust fan system that serves the thermal zone
Units	Text or other unique reference to an exhaust fan system defined in the secondary systems section.
Input Restrictions	As designed
Standard Design	Same as the proposed design

Laboratory Exhaust Rate Type

Applicability	All zones comprised of Laboratory, Scientific or Laboratory, Equipment Room space
Definition	The type of load that dictates lab exhaust rate requirements
Units	List, either:
	Hood dominated
	Load dominated
Input Restrictions	As designed
Standard Design	Same as the proposed design

Exhaust Air Flow Rate

Applicability	All thermal zones
Definition	Rate of exhaust from a thermal zone
	cfm
Input Restrictions	

Units

As designed for non-process zones

As designed for kitchen exhaust systems

For laboratory zones, the exhaust air flow rate is defaulted to:

15 ACH for hood dominated spaces, or

6 ACH for load dominated spaces

The design exhaust air flow rate may be specified by the user, but shall not be less than 6 ACH. The minimum design exhaust air flow for systems with variable flow is 10 ACH.

Standard Design Same as the proposed design but not above the maximum standard design ventilation rates listed in Appendix 5.4A for spaces that do not include covered processes. Exception for buildings with over 5,000 cfm of kitchen exhaust: the baseline is a function of the Kitchen Exhaust Hood Length, Kitchen Exhaust Hood Style and Kitchen Exhaust Hood Cooking Duty, and is determined by Title 24 Standards Table 140.9-A.

Exhaust Minimum Air Flow Rate

Applicability All laboratory zones

Definition Rate of exhaust from a zone

Units cfm

Input Restrictions As designed for non-process zones

For laboratory zones, the exhaust air flow rate is the maximum of the hood scheduled exhaust air flow rate and the minimum ventilation rate

Standard Design For laboratory systems with Exhaust Fan Control Method of Constant Flow, the exhaust minimum air flow rate is 6 ACH. For laboratory systems with Exhaust Fan Control Method of variable flow, variable speed drive, the exhaust minimum air flow rate is 4 ACH.

Exhaust Fan Schedule

Applicability All thermal zones

Definition Schedule indicating the pattern of use for exhaust air from the thermal zone.

Units Data structure: schedule, fraction

Input Restrictions As designed for non-covered process spaces

Exhaust schedules for kitchen exhaust hoods in the building with total flow greater than or less than 5,000 cfm are prescribed and specified in Appendix 5.4B.

For laboratory spaces, if the exhaust is constant flow, the schedule shall be fixed at 0.90 for all hours of the year (24/7).

For laboratory spaces, if the exhaust is variable flow, all the schedule shall be prescribed at the values in Appendix 5.4B.

Standard Design Same as the proposed design for non-covered process spaces

Exhaust schedules for kitchen exhaust hoods for flow less than 5,000 cfm and for flow greater than 5,000 cfm are prescribed and specified in Appendix 5.4B.

For laboratory spaces, if the proposed design exhaust air flow rate is less than 10 ACH, the schedule shall be prescribed at 0.90 for all hours of the year (24/7).

For laboratory spaces, if the proposed design exhaust air flow rate is 10 ACH or greater, than the exhaust fan schedule shall be prescribed at the values defined in Appendix 5.4B for variable flow.

5.6.5.4 Outdoor Air Ventilation

Ventilation Source

Applicability All thermal zones

Definition The source of ventilation for an HVAC system. The choices are:

- Natural (by operable openings)
- Forced (by fan)

Units List: natural or forced

Input Restrictions For residential units and hotel/motel guest rooms, forced ventilation. For all other occupancies, as designed.

Standard Design For residential units, forced ventilation. Ventilation shall be provided by exhaust fans in each zone. For all other occupancies, set to Forced Ventilation.

Design Ventilation Rate

Applicability All thermal zones

Definition The quantity of ventilation air that is provided to the space for the specified thermal zone at maximum occupancy

Units cfm

Input Restrictions As designed, but not lower than code minimum (default value) per §120.1.

To accommodate transfer air requirements for makeup air for exhaust from other zones, the design ventilation rate may be up to 120% of the proposed design exhaust rate for all spaces and thermal zones on a building story without penalty.

For each high-rise residential dwelling unit: the minimum ventilation rate is defined by:

Minimum Ventilation Rate = (0.06 cfm/ft^2 * area) + (5 cfm/person * Total Number of Occupants per dwelling unit),

Where the Total Number of Occupants defaults to floor area in sf / 200, but may be adjusted to the design value

For hotel/motel guestroom spaces:

Minimum Ventilation Rate = 30 cfm if Guestroom area < 500 sf; otherwise 0.15 cfm/sf x Guestroom Floor Area

For all other spaces:

The minimum required ventilation rate for each space shall be the larger of 15 cfm times the design occupancy from Appendix 5.4A or the conditioned floor area times the applicable ventilation rate from Appendix 5.4A.

Standard Design

If the total exhaust airflow requirement on the building floor does not exceed the total ventilation requirement, then the standard design outside air ventilation rate shall be the same as the proposed. If the proposed ventilation rate exceeds the default minimum, the standard design ventilation rate for each space shall be the proposed rate uniformly reduced such that the total ventilation air delivered to the building story is equal to the total minimum ventilation air rate:

$\text{Design Ventilation Rate}_{std} = \text{Design Ventilation Rate}_{prop} \times (\text{BFVent}_{std} / \text{BFVent}_{prop})$

Where

BFVent_{min} is the Building Floor design minimum required ventilation flow, as specified by the Standards, and

BFVent_{prop} is the Building Floor design ventilation flow for the proposed design.

If the total exhaust airflow requirement on the building floor exceeds the minimum required ventilation flow requirements:

The standard design outside air ventilation rate shall be the same as the proposed up to 120% of the design exhaust air flow. If the proposed ventilation rate exceeds 120% of the design exhaust flow, the standard design ventilation rate for each space shall be the proposed rate uniformly reduced such that the total ventilation air delivered to the building story is equal to 120% of the design exhaust flow rate:

$\text{Design Ventilation Rate}_{std} = \text{Design Ventilation Rate}_{prop} \times (\text{BFExh}_{Prop} \times 1.2/\text{BFVent}_{prop})$

Where

BFExh_{prop} is the Building Floor design exhaust flow, and

BFVent_{prop} is the Building Floor design ventilation flow for the proposed design

Building Floor Ventilation Requirement

Applicability	Internal variable, calculated for each building story (floor)
Definition	The total outside air ventilation airflow requirement for all spaces on a building story or floor. This is calculated by summing the ventilation levels for each space, and comparing it to the minimum required ventilation rate and the design exhaust air flow requirements.
Units	Cubic feet per minute (cfm)
Input Restrictions	Not a user input. This is derived by summing the ventilation and exhaust air flows from all spaces on the building floor.
Standard Design	This is calculated by the following procedure: 1. Calculate the Proposed Ventilation for the building story as the sum of design ventilation flow for each space included on a building story, including all spaces except space designated as ‘Lab’ space. 2. Calculate the Proposed Exhaust for the building story as the sum of design exhaust flow for each space on the building story, including all spaces except spaces designated as ‘Lab’ space. 3. Calculate the Code Minimum Ventilation requirement as the sum of all minimum required ventilation airflows, as defined by Appendix 5.4A, for all spaces in the building story. 4. If the Proposed Exhaust is greater than the Code Minimum Ventilation Rate, then the:

a. Total Standard Design Building Story Ventilation Requirement shall be:

Standard Ventilation = Min(Proposed Ventilation, Proposed Exhaust x 1.2)

Otherwise:

b. Standard Ventilation = Min(Code Minimum Ventilation, Proposed Ventilation)

Minimum Ventilation Rate	
Applicability	All thermal zones, excluding unconditioned spaces
Definition	The minimum quantity of ventilation air that must be provided to the space when it is occupied.
Units	cfm
Input Restrictions	As designed, but not lower than code minimum (default value) per §120.1. The default value shall be the larger of 15 cfm times the default occupancy times the occupancy ventilation fraction, or the conditioned floor area times the applicable ventilation rate from Appendix 5.4A. For spaces where demand control ventilation is installed, the minimum ventilation rate is specified by the greater of the rate in Table 120.1-A or 15 cfm times the scheduled occupancy for that hour;
Standard Design	For spaces where demand control ventilation is required, the minimum ventilation rate is specified by the greater of the rate in Appendix 5.4A or 15 cfm times the scheduled occupancy for that hour; For systems serving laboratories, the airflow minimum for each lab space shall be 6 ACH for constant flow systems, or 4 ACH for variable flow systems.

Ventilation Control Method	
Applicability	All thermal zones
Definition	The method used to determine outside air ventilation needed for each hour in the simulation. This information is reported to the system serving the zone. The method of controlling outside air at the system level in response to this information is discussed under secondary systems. Options at the zone level are: • Occupant sensors: When the space is occupied according to the prescribed occupancy schedule, the outside air requirement is equal to the *design ventilation rate*; otherwise, the outside air requirement is either 25% of the *minimum ventilation rate or scheduled off (0)*. • CO_2 sensors in the space: The outside air is varied to maintain a maximum CO_2 concentration in the space. This shall be approximated by multiplying the ventilation rate per occupant times the number of occupants for that hour. (When turnstile counts are used to automatically adjust ventilation levels based on occupancy, this method may also be used.) • Fixed ventilation rate. Outside air is delivered to the zone at a constant rate and is equal to the design ventilation rate (see above).
Units	List (see above)
Input Restrictions	As designed. If the space includes a design occupant density greater than or equal to 25 persons per 1,000 ft^2, and the system includes an airside economizer, the input is restricted to *CO_2 sensors in the space* (mandatory requirement except for classrooms).
Standard Design	For Title 24 compliance, if the default occupancy from Appendix 5.4B is greater than or

equal to 25 persons per 1,000 ft² and the system includes and airside economizer, and the system is not serving a classroom space, set control method to *CO_2 sensors in the space*, otherwise set to *fixed ventilation rate*.

5.7 HVAC Secondary Systems

This group of building descriptors relate to the secondary HVAC systems. There is not a one-to-one relationship between secondary HVAC system components in the proposed design and the baseline building since the baseline building system is determined from building type, size and number of floors. Where the Standard Design for a building descriptor varies with the standard design HVAC system selection, the baseline is specified as a table with the applicable value for each of the 11 baseline systems.

The HVAC standard design (baseline) systems are described in the summary tables below for reference. The details of individual building descriptor definitions can be found in section 5.7.1 and in subsections under 5.7.

Table 18 – System #1 Description

System Description:	Packaged Terminal Air Conditioner (#1)
Supply Fan Power:	N/A (fan power integral to unit efficiency), ventilation provided naturally through operable windows
Supply Fan Control:	Constant volume
Min Supply Temp:	$50 \le T \le 60$ DEFAULT: 20F below return air temperature
Cooling System:	Direct expansion (DX)
Cooling Efficiency:	Minimum SEER or EER based on equipment type and output capacity of standard design unit(s). Adjusted EER is calculated to account for supply fan energy.
Maximum Supply Temp:	$85 \le T \le 110$ DEFAULT: 100
Heating System:	Gas furnace (#3) or heat pump (#4)
Heating Efficiency:	Minimum AFUE, Thermal Efficiency, COP or HSPF based on equipment type and output capacity of standard design unit(s).
Economizer:	None
Ducts:	N/A (unducted)

Table 19 – System #2 Description

System Description:	Four-Pipe Fan Coil (#2)
Supply Fan Power:	0.35 W/cfm
Supply Fan Control:	Cycles with load
Min Supply Temp:	$50 \le T \le 60$ DEFAULT: 20F below return air temperature
Space Temp Control:	SAT is fixed at 55F. Fan cycles to meet the load.
Cooling System:	Chilled water
Cooling Efficiency:	Minimum kW/ton and IPLV per Path B chiller requirements in Title 24 Section 110.2
Maximum Supply Temp:	$85 \le T \le 110$ DEFAULT: 100
Heating System:	Boiler
Heating Efficiency:	Minimum AFUE, Thermal Efficiency per Section 110.2 of Title 24 Part 6 for the applicable heating capacity
Economizer:	None
Ducts:	N/A (unducted)

Table 20 – System #3 Description

System Description:	Packaged Single Zone with Gas Furnace/Electric Air Conditioning (#3)
Supply Fan Power:	See Section 5.7.3
Supply Fan Control:	Constant volume
Min Supply Temp:	$50 \le T \le 60$ DEFAULT: 20F below return air temperature
Cooling System:	Direct expansion (DX)
Cooling Efficiency:	Minimum SEER or EER based on equipment type and output capacity of standard design unit(s). Adjusted EER is calculated to account for supply fan energy.
Maximum Supply Temp:	$85 \le T \le 110$ DEFAULT: 100
Heating System:	Gas furnace (#3)
Heating Efficiency:	Minimum AFUE, Thermal Efficiency, COP or HSPF based on equipment type and output capacity of standard design unit(s).
Economizer:	**Integrated economizer** with differential dry-bulb high limit, when mechanical cooling output capacity of the standard design as modeled in the compliance run by the compliance software is over 54,000 Btu/hr
Ducts:	For ducts installed in unconditioned buffer spaces or outdoors as specified in §140.4(l), the duct system efficiency shall be as modified by accounting for duct leakage rate from HERS testing,; see applicable building descriptors.

Table 21 – System #5 Description

System Description:	Packaged VAV with Boiler and Reheat
Supply Fan Power:	See Section 5.7.3
Supply Fan Control:	VAV - variable speed drive
Relief Fan Control:	See fan section
Minimum Supply Temp:	$50 \leq T \leq 60$ DEFAULT: 20F below return air temperature
Cooling System:	Direct expansion (DX)
Cooling Efficiency:	Minimum efficiency based on average standard design output capacity of equipment unit(s)
Maximum Supply Temp:	$90 \leq T \leq 110$ DEFAULT: 105
Heating System:	Gas boiler
Hot Water Pumping System	Variable flow (2-way valves) riding the pump curve
Heating Efficiency:	Minimum efficiency based on average standard design output capacity of equipment unit(s)
Economizer:	Integrated dry bulb economizer with differential dry-bulb limit

Table 22 – System #6 Description

System Description:	Chilled Water VAV With Reheat
Supply Fan Power:	See Section 5.7.3
Supply Fan Control:	VAV - variable speed drive
Return Fan Control:	Same as supply fan
Minimum Supply Temp:	$50 \leq T \leq 60$ DEFAULT: 20F below return air temperature
Cooling System:	Chilled water
Chilled Water Pumping System	Variable flow (2-way valves) with a VSD on the pump if three or more fan coils or air handlers. Constant volume flow with water temperature reset control if less than three fan coils or air handlers. Reset supply pressure by demand if standard system has DDC controls.
Cooling Efficiency:	Minimum efficiency based on standard design output capacity of equipment unit(s)
Maximum Supply Temp:	$90 \leq T \leq 110$ DEFAULT: 105
Heating System:	Gas boiler
Hot Water Pumping System	Variable flow (2-way valves) riding the pump curve if three or more fan coils or air handlers. Constant volume flow with water temperature reset control if less than three fan coils or air handlers. Reset supply pressure by demand.
Heating Efficiency:	Minimum efficiency based on standard design output capacity of equipment unit(s)
Economizer:	Integrated dry bulb economizer with differential dry-bulb limit

Table 23 – System #7 Description

System Description:	Single-zone VAV System
Supply Fan Power:	See Section 5.7.3
Supply Fan Control	Variable-speed drive
Minimum Supply Temp:	50 $\leq$ T $\leq$ 60 DEFAULT: 20F below return air temperature
Supply Temp Control:	Supply air temperature setpoint shall be linearly reset from minimum at 50% cooling load and above to maximum at 0% cooling load. Fan volume shall be linearly reset from 100% air flow at 100% cooling load to minimum air flow at 50% cooling load and below. Minimum fan volume setpoint shall be 50%. (this is effectively an “airflow first” sequence”)
Cooling System:	Direct expansion
Cooling Efficiency:	Minimum efficiency based on the standard output capacity of specific equipment unit(s)
Compressor Stages:	Two to four (See minimum unloading ratio requirement)
Maximum Supply Temp:	90 $\leq$ T $\leq$ 110 DEFAULT: 100
Heating System:	Gas furnace
Hot Water Pumping System	Variable flow (2-way valves) riding the pump curve if three or more fan coils. Constant volume flow with water temperature reset control if less than three fan coils. Reset supply pressure by demand if standard system has DDC controls.
Heating Efficiency:	Minimum efficiency based on the standard output capacity of specific equipment unit(s)
Economizer:	Integrated dry bulb economizer with differential dry-bulb high limit

Table 24 – System #9 Description

System Description:	Heating and ventilation only system
Supply Fan Power:	See fan power details
Supply Fan Control	Constant Volume
Minimum Supply Temp:	N/A
Cooling System:	None
Cooling Efficiency:	N/A
Maximum Supply Temp:	90 $\leq$ T $\leq$ 110 DEFAULT: 100
Heating System:	Gas furnace
Hot Water Pumping System	N/A
Heating Efficiency:	Minimum efficiency based on the standard output capacity of specific equipment unit(s)
Economizer:	TBD

Table 25 – System #10 Description

System Description:	Computer room air handler (CRAH)
Supply Fan Power:	0.49 W/cfm at design air flow where economizer is required, 0.39 W/cfm where economized is not required.
Supply Fan Control	Variable speed drive. Fan power part-load curve is for “VSD with static pressure reset”.
Minimum Supply Temp:	60F
Cooling System:	Single Zone VAV with Chilled water cooling source
Cooling Efficiency:	Same as System #6 (Built-up VAV)
Maximum Supply Temp:	80F
Heating System:	None
Economizer:	Integrated 100% outside air economizer with differential dry-bulb limit
Supply Temp Control:	**VAV:** Supply air temperature setpoint shall be reset between 60F and 80F, and fan volume shall be reset between 100% and 50% flow, depending on cooling load. Minimum fan volume setpoint shall be 50%.

Table 26 – System #11 Description

System Description:	Computer room air conditioner (CRAC)
Supply Fan Power:	0.49 W/cfm at design flow (see equipment sizing) where economizer is required, 0.39 W/cfm where economizer is not required.
Supply Fan Control	Constant speed if the computer room receptacle load is less than 17.5 kW, otherwise: variable speed drive. Fan power curve for VSD is 'VSD with static pressure reset'.
Relief Fan Control:	No relief fan
Minimum Supply Temp:	60F
Cooling System:	Single zone Air-cooled DX
Cooling Capacity:	Equipment design CFM and cooling capacity sized at 115% of the capacities generated from a system sizing run. One system per zone.
Cooling Efficiency:	Appliance Standards Table C-9
Maximum Supply Temp:	80F
Heating System:	None
Economizer:	Integrated 100% outside air economizer with differential dry-bulb limit if the net cooling capacity is greater than 54,000 Btu/h
Supply Temp Control:	**VAV:** Supply air temperature setpoint shall be between 60F and 80F and fan supply air volume shall be reset between 100% and 50% of the rated fan condition, depending on the cooling load. Minimum fan volume setpoint shall be 50%. **CV:** supply air temperature setpoint modulates to meet the load.

Table 27 – System #12 Description

System Description:	Laboratory HVAC System
Supply Fan Power:	See Supply Fan Static Pressure, Supply Fan Efficiency, and Supply Fan Motor Efficiency for standard design specifications
Supply Fan Control	Variable-speed drive
Return Fan Control:	No return fans
Exhaust Fan Control:	Variable volume, variable-speed drive if total building laboratory exhaust air flow rate is greater than 2,000 cfm and 10 ACH or greater; constant volume otherwise.
Ventilation:	Same as proposed but subject to a Minimum 6 ACH; system is 100% outside air
Minimum Supply Temp:	55F
Cooling System:	PVAV with air-cooled DX if ***total lab*** floor area <150,000 ft^2; water-cooled chiller if greater than 150,000 ft^2 floor area
Cooling Capacity:	Equipment fan CFM and cooling capacity sized at 115% of the capacities determined using a sizing run. One laboratory system per floor when total building laboratory floor area is 10,000 ft2 or greater, otherwise one laboratory system per zone.
Cooling Efficiency:	Minimum efficiency requirements per Section 110.2
Maximum Supply Temp:	95
Heating System:	Gas furnace if less than 10,000 ft^2; hot water boiler if greater than 10,000 ft^2
Economizer:	Integrated 100% outside air economizer with differential dry-bulb limit
Supply Temp Control:	**VAV:** Supply air temperature setpoint shall be reset upwards by 5F based on warmest zone, and fan volume shall be reset between100% and 50% flow, depending on cooling load. Minimum fan volume setpoint shall be 50%. **CV:** supply air temperature setpoint modulates to meet the load.

Table 28 – System #13 Description

System Description:	Kitchen HVAC System
Supply Fan Power:	Fixed supply fan static pressure – see Section 5.7.3
Supply Fan Control	Constant speed if total exhaust airflow rate is greater than or equal to 2,000 cfm, otherwise: variable speed drive. Fan power ratio at part load is determined by the part load ratio and the static pressure reset system curve
Return Fan Control:	No return fans
Exhaust Fan Control:	Variable volume, variable-speed drive if total exhaust air flow rate > 5,000 cfm; constant volume otherwise
Minimum Supply Temp:	20F below space temperature setpoint
Cooling System:	PVAV with air-cooled DX if floor area < 50,000 ft^2; water-cooled chiller if greater 50,000 ft^2 floor area
Cooling Capacity:	Cooling capacity sized at 115% of the calculated room load. Fan airflow sizing based on exhaust airflow requirements. One fan system per room.
Cooling Efficiency:	Minimum efficiency requirements per Section 110.2
Maximum Supply Temp:	95
Heating System:	Gas furnace if less than 50,000 ft^2; hot water boiler if greater than 50,000 ft^2
Economizer:	None
Supply Temp Control:	**VAV:** Supply air temperature setpoint shall be linearly reset from minimum at 50% cooling load and above to maximum at 0% cooling load. Fan volume shall be linearly reset from 100% air flow at 100% cooling load to minimum air flow at 50% cooling load and below. Minimum fan volume setpoint shall be 50%. (this is effectively an “airflow first” sequence”) **CV:** supply air temperature modulates to meet the load.

5.7.1 Basic System Information

HVAC System Name

Applicability	All system types
	A unique descriptor for each HVAC System
Units	Text, unique
Input Restrictions	When applicable, this input should match the tags that are used on the plans.
Standard Design	None

System Type

Applicability All system types

Definition A unique descriptor which identifies the following attributes of an HVAC System:

- Number of air decks (one to three);
- Constant or variable air flow;
- Type of terminal device; and
- Fan configuration for multiple deck systems.

Units List from the choices below

Input Restrictions List

PTAC – Packaged Terminal Air Conditioner

PTHP – Packaged Terminal Heat Pump

PSZ-AC – Packaged Single Zone

	PSZ-HP – Packaged Single Zone Heat Pump
	PVAV – Packaged VAV with Reheat
	VAV* – VAV with Reheat
	PSZVAV* – Single Zone VAV
	PSZVAVHP – Single Zone VAV Heat Pump
	HV – Heating and Ventilation Only
	CRAC – Computer Room Air Conditioner
	CRAH – Computer Room Air Handler
	FPFC – Four-pipe fan coil
	DFDD – Dual-fan dual duct
	RADFLR – Radiant floor heating and cooling
	WSHP – water-source heat pump
	* Choice includes series and parallel fan-powered boxes as zone terminal units
Standard Design	Based on the prescribed system type in the HVAC system map (see Section 5.1.2 Table 4). The baseline system types are shown in the table below.

Table 29 – Baseline Building System Type

Baseline Building System Type
System 1 – PTAC
System 2 – FPFC
System 3 – PSZ-AC
System 5 – Packaged VAV with Reheat
System 6 – VAV with Reheat
System 7 – PSZ-SZVAV
System 9 – Heating and Ventilation
System 10 – CRAC Unit
System 11 – CRAH Unit
System 12 – LAB
System 13 – Kitchen

Air Distribution Type

Applicability	All system types
Definition	Type of air distribution system that is coupled with the HVAC system. The choices are (overhead) mixing ventilation system, underfloor air distribution system (UFAD), and displacement ventilation system (DV).
Units	List: Mixing, UFAD, DV
Input Restrictions	As designed
Standard Design	Mixing

Thermal zone List	
Applicability	All system types
Definition	Comprehensive list of all thermal zones served by a given HVAC system.
Units	None
Standard Design	Same as the proposed design
Input Restrictions	As designed

Total Cooling Capacity	
Applicability	All system types
Definition	The installed cooling capacity of the project. This includes all: • Chillers; • Built-up DX; and, • Packaged cooling units.
Units	Cooling tons (12,000 Btu/h per ton)
Input Restrictions	As designed.
Standard Design	Autosize. The cooling capacity shall be oversized by 15%. If the number of unmet load hours exceeds 150, increase the cooling capacity according to the procedures in Chapter 2.

System Priority	
Applicability	Any systems where either space conditioning is decoupled from ventilation, or where multiple systems serve a thermal zone
Definition	The priority of a system in controlling a thermal zone to maintain heating and cooling setpoints. For instance, for a zone that is conditioned by a zone system but has ventilation provided by a separate dedicated outside air (DOAS) system, if the DOAS system has first priority, it will attempt to directly control the space temperature, and the zonal system will be enabled only when the DOAS system cannot meet the space load. If the DOAS system has lower priority, the zonal system will meet the space load, and the DOAS system will be used primarily for ventilation purposes (allowing the discharge air temperature to float within a range – see *Cooling Supply Air Temperature Control*).
Units	None
Input Restrictions	1 (first priority) or 2 (second priority)
Standard Design	As designed

5.7.2 System Controls

5.7.2.1 Control System Type

Control System Type	
Applicability	All HVAC systems that serve more than one control zone, as well as the hydronic systems that serve building HVAC systems.

Definition	The type of control system for multizone HVAC systems and their related equipment. This input affects the proposed design system specification for zone level controls, supply air temperature reset controls, ventilation controls and fan and pump static pressure part-load curves. See the following building descriptors: Ventilation Control Method Terminal Heating Control Type Pump Part-Load Curve Fan Part-load Curve
Units	None
Input Restrictions	List: can be one of the following inputs DDC Control to the Zone Level – direct digital control systems with control to the zone level Other – other control systems, including pneumatic and DDC systems without control to the zone level
Standard Design	DDC Control to the Zone Level

5.7.2.2 Schedules

Cooling Schedule	
Applicability	All cooling systems
Definition	A schedule that represents the availability of cooling
Units	Data structure: schedule, on/off
Input Restrictions	Schedule Group is prescribed in Appendix 5.4A and schedule values are prescribed in Appendix 5.4B. See Section 2.3.3 on how software shall assign schedules when the spaces served by the system are assigned to different schedule groups in Appendix 5.4A.
Standard Design	Same as the proposed design

Heating Schedule	
Applicability	All systems
Definition	A schedule that represents the availability of heating
Units	Data structure: schedule, on/off
Input Restrictions	Schedule Group is prescribed in Appendix 5.4A and schedule values are prescribed in Appendix 5.4B. See Section 2.3.3 on how software shall assign schedules when the spaces served by the system are assigned to different schedule groups in Appendix 5.4A.
Standard Design	Same as the proposed design

Air-Handler Schedule	
Applicability	All systems that do not cycle with loads
Definition	A schedule that indicates when the air handler operates continuously
Units	Data structure: schedule, on/off
Input Restrictions	

	Schedule Group is prescribed in Appendix 5.4A and schedule values are prescribed in Appendix 5.4B. See Section 2.3.3 on how software shall assign schedules when the spaces served by the system are assigned to different schedule groups in Appendix 5.4A. When a fan system serves several occupancies, the fan schedule must remain ON to serve the operating hours of each occupancy.
Standard Design	Same as the proposed design

Air Handler Fan Cycling

Applicability	All fan systems
Definition	This building descriptor indicates whether the system supply fan operates continuously or cycles with building loads. The fan systems in most commercial buildings operate continuously.
Units	List: Continuous or Cycles with loads
Input Restrictions	For four-pipe fan coil systems, *As Designed* if the HVAC system serving the spaces includes a dedicated outside air source for ventilation; otherwise, fixed at *Continuous*. For mechanical ventilation systems with operable windows, *As Designed* if the system includes interlocks or automatic window controls to prevent simultaneous operation; otherwise the proposed design input is fixed at *Continuous*. For all other systems, fixed at *Continuous*.
Standard Design	*Cycles with loads* for PTAC or FPFC systems; *Continuous* for all other standard design system types.

Optimal Start Control

Applicability	Systems with the control capability for flexible scheduling of system start time based on building loads.
Definition	Optimal start control adjusts the start time of the HVAC unit such that the space is brought to setpoint just prior to occupancy. This control strategy modifies the heating, cooling, and fan schedules.
Units	Boolean (Yes/No)
Input Restrictions	No (not allowed)
Standard Design	Not Not applicable

Night-Cycle HVAC Fan Control

Applicability	All systems
Definition	The control of an HVAC system that is triggered by the heating or cooling temperature setpoint for thermal zones during periods when the heating, cooling and fan systems are scheduled to be off. For this control, the space is controlled to the setback or setup temperature only; this control is not equivalent to a night purge control. The choices are: • Cycle on call from any zone • Cycle on call from the primary control zone • Stay off

- Cycle zone fans only (for systems with fan-powered boxes) Restart fans below given ambient temperature.

Units None

Input Restrictions

Cycle on call from any zone, except for systems with fan-powered boxes, where either Cycle on call from any zone or Cycle zone fans only is allowed.

Standard Design Cycle on call from any zone

5.7.2.3 Cooling Control

Cooling Supply Air Temperature

Applicability Applicable to all systems

Definition The supply air temperature setpoint at design cooling conditions

Units Degrees Fahrenheit (°F)

Input Restrictions As designed

Standard Design 15°F below the space temperature setpoint for interior zones that are served by multiple zone systems; for all other zones,

20°F below the space temperature setpoint

Cooling Supply Air Temperature Control

Applicability Any cooling system

Definition The method of controlling the supply air temperature. Choices are:

- No control – for this scheme the cooling coils are energized whenever there is a call for cooling
- Fixed (constant)
- Reset by warmest zone, airflow first
- Reset by warmest zone, temperature first
- Reset by outside air dry-bulb temperature
- Scheduled setpoint
- Staged setpoint (for Single Zone VAV and DX with multiple stages)
- Fixed Dual Setpoint
- Scheduled Dual Setpoint

Units List (see above)

Input Restrictions As designed

Standard Design For baseline building systems 1 through 4, the SAT control is fixed. For systems 5 through 8,10 and 11, the SAT control shall be reset by warmest zone, airflow first. For system 9 (heating and ventilation) this input is not applicable.

Cooling Reset Schedule by OSA

Applicability When the proposed design resets SAT by outside air dry-bulb temperature

Definition A linear reset schedule that represents the SAT setpoint as a function of outdoor air dry-bulb temperature. This schedule is defined by the following data points (see Figure 10):

- The coldest cooling supply air temperature
- The corresponding (hot) outdoor air dry-bulb setpoint
- The warmest cooling supply air temperature
- The corresponding (cool) outdoor air dry-bulb setpoint

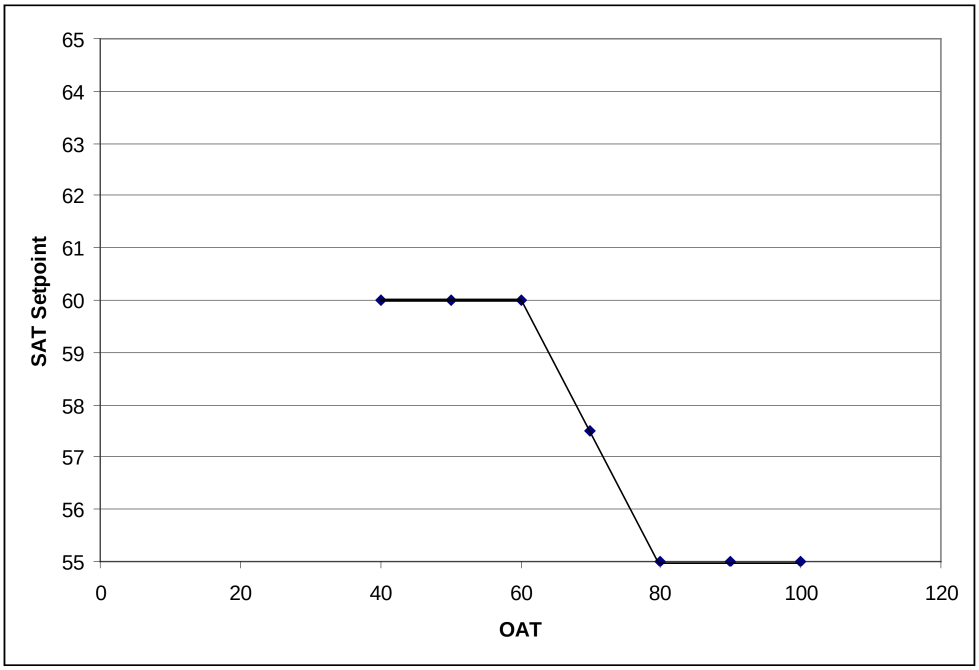


Figure 10 – SAT Cooling Setpoint Reset based on Outdoor Air Temperature (OAT)

Units Data structure (two matched pairs of SAT and OAT, see above)

Input Restrictions

Standard Design Not applicable

5.7.2.4 Heating Control

Preheat Setpoint

Applicability Systems with a preheat coil located in the outside air stream

Definition The control temperature leaving the preheat coil

Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	Not Applicable

Heating Supply Air Temperature

Applicability	All systems
Definition	The supply air temperature leaving the air handler when the system is in a heating mode (not the air temperature leaving the reheat coils in VAV boxes)
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	95°F for system types 1-4; 70°F for multiple zone systems; no heating for data centers and computer rooms

Heating Supply Air Temperature Control

Applicability Systems with the capability to vary heating SAT

Definition The method of controlling heating SAT. Choices are:

- No control – the heating coil is energized on a call for heating, but the supply air temperature is not directly controlled, but instead is dependent on the entering air temperature, the heating capacity and the airflow rate.
- Fixed (constant)
- Reset by coldest zone, airflow first
- Reset by coldest zone, temperature first
- Reset by outside air dry-bulb temperature
- Staged setpoint
- Scheduled setpoint

Units Degrees Fahrenheit (°F)

Input Restrictions As designed

Standard Design Fixed (constant)

Heating Reset Schedule by OSA

Applicability Systems that reset the heating SAT by outside dry-bulb temperature (this typically applies to dual-duct systems or to single zone systems with hydronic heating coils)

Definition A linear reset schedule that represents the heating supply air temperature or hot deck supply air temperature (for dual duct systems) as a function of outdoor air dry-bulb temperature. This schedule is defined by the following data points (see Figure 11):

- The hottest heating supply air temperature
- The corresponding (cold) outdoor air dry-bulb threshold
- The coolest heating supply air temperature
- The corresponding (mild) outdoor air dry-bulb threshold

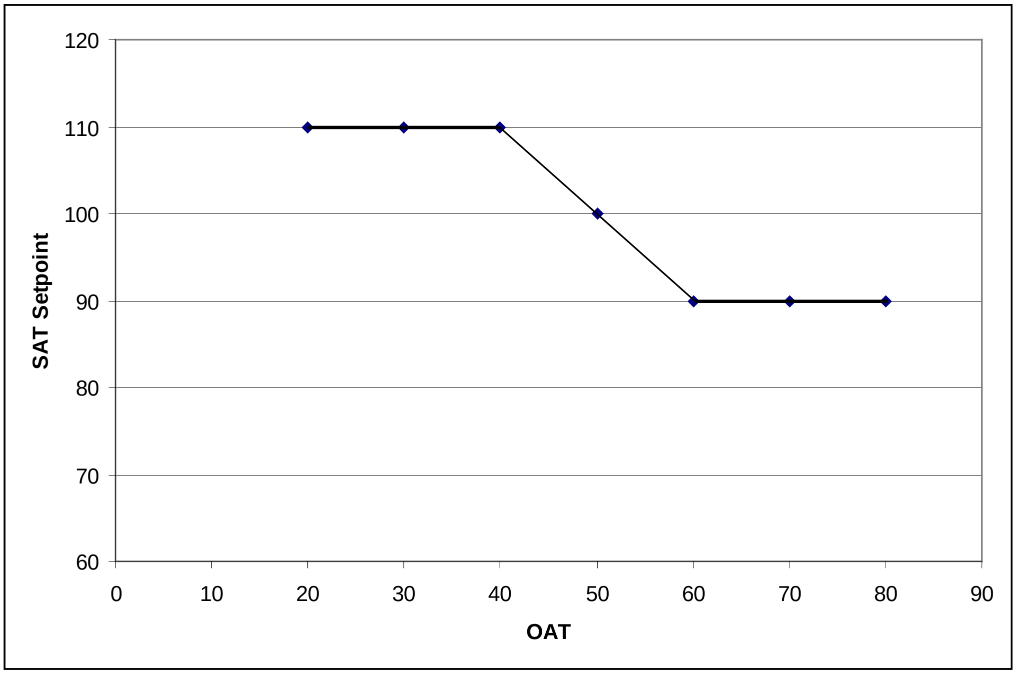


Figure 11 – Example of SAT heating setpoint reset based on outdoor air temperature (OAT).

Units	Data structure (°F)
Input Restrictions	As designed
Standard Design	Not applicable

5.7.3 Fan Systems

5.7.3.1 Baseline Building Fan System Summary

The baseline building fan system is summarized in this section. See Section 5.7.1, Table 27 for the HVAC baseline building system mapping.

When the proposed design has exhaust fans (toilets or kitchens), or fume hood exhaust systems, the baseline building has the same systems.

5.7.3.2 Supply Fans

Fan System Modeling Method	
Applicability	All fan systems
Definition	Software commonly models fans in three ways. The simple method is for the user to enter the electric power per unit of flow (W/cfm). This method is commonly used for unitary equipment and other small fan systems. A more detailed method is to model the fan as a system whereby the static pressure, fan efficiency, part-load curve, and motor efficiency are specified at design conditions. A third method is to specify brake

	horsepower at design conditions instead of fan efficiency and static pressure. This is a variation of the second method whereby brake horsepower is specified in lieu of static pressure and fan efficiency. The latter two methods are commonly used for VAV and other larger fan systems.
Units	List: power-per-unit-flow, static pressure or brake horsepower
Input Restrictions	As designed. Either the static pressure or brake horsepower method shall be used. The user is required to enter the brake horsepower and motor horsepower of all fans.
Standard Design	The baseline building shall use the static pressure method for all HVAC systems except the four-pipe fan coil system, which shall use the power-per-unit-flow method.

Supply Fan Design Airflow

Applicability	All fan systems
Definition	The air flow rate of the supply fan(s) at design conditions. This building descriptor sets the 100% point for the fan part-load curve.
Units	cfm
Input Restrictions	As designed. For multiple deck systems, a separate entry should be made for each deck.
Standard Design	The program shall automatically size the air flow at each thermal zone to meet the loads. The design air flow rate calculation shall be based on a 20 degree temperature differential between supply air and the room air 20°F temperature differential between the supply air and the return air for exterior zones and a 15°F temperature differential for interior zones served by multiple zone systems. The design supply air flow rate is the larger of the flow rate required to meet space conditioning requirements and the required ventilation flow rate. The supply fan design air flow rate shall be the system airflow rate that satisfies that coincident peak of all thermal zones at the design supply air temperature (55F).

Fan Control Method

Applicability All fan systems

Definition A description of how the supply (and return/relief) fan(s) are controlled. The options include:

- Constant volume
- Variable-flow, inlet or discharge dampers
- Variable-flow, inlet guide vanes
- Variable-flow, variable speed drive (VSD)
- Variable-flow, variable pitch blades
- Variable-flow, other
- Two-speed
- Constant volume, cycling (fan cycles with heating and cooling)

Units List (see above)

Input Restrictions As designed

Standard Design Applicable to variable air volume systems

Based on the prescribed system type. Refer to the HVAC System Map in 5.1.2

Table 30 – Baseline Building Fan Control Method

Baseline building System	Fan Control Method
System 1 – PTAC	Constant volume, cycling
System 2 – FPFC	Constant volume, cycling
System 3 – PSZ-AC	Constant volume
System 5 – Packaged VAV with Reheat	Variable-flow, variable speed drive (VSD)
System 6 – VAV with Reheat	Variable-flow, variable speed drive (VSD)
System 7 – PSZ, Single Zone VAV	Variable-flow, variable-speed drive (VSD)
System 9 – Heating and Ventilation	Constant volume
System 10 – CRAH Units	Variable-flow, variable speed drive (VSD)*
System 11 – CRAC Units	Variable-flow, variable speed drive (VSD)*

* For CRAH Units, fan volume shall be linearly reset from 100% air flow at 100% cooling load to minimum airflow at 50% cooling load and below.

Supply Fan Brake Horsepower

Applicability All fan systems, except those specified using the power-per-unit-flow method

Definition The design shaft brake horsepower of each supply fan. This input does not need to be supplied if the Supply Fan kW is supplied.

Units Horsepower (hp)

Input Restrictions As designed. If this building descriptor is specified for the proposed design, then the *Static Pressure* and *Fan Efficiency* are not.

The compliance software shall apply the following rule to specify the proposed design bhp, based on user input:

A Standard Motor Size table (hp) is defined as: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200

The user-entered brake horsepower for the proposed design is compared against the next smaller motor size from the user-entered Supply Fan Motor Horsepower. The proposed design Supply Fan Brake Horsepower (bhp) is set to the maximum of the user-entered bhp and 95% of the next smaller motor horsepower:

Proposed bhp = max(User bhp, 95% ×MHP_{i-1})

Where User bhp is the user-entered supply fan brake horsepower,

MHPi is the proposed (nameplate) motor horsepower

MHPi-1 is the next smaller motor horsepower from the Standard Motor Size table above. For example, if the proposed motor horsepower is 25, the next smaller motor horsepower from the table above is 20, and 95% of the next smaller motor horsepower is 19.

Standard Design Not applicable

Supply Fan Motor Horsepower

Applicability All fan systems, except those specified using the power-per-unit-flow method

Definition The motor nameplate horsepower of the supply fan

Units	List: chosen from a list of standard motor sizes: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200
Input Restrictions	As designed. This building descriptor is required for the static pressure or the brake horsepower methods
Standard Design	The brake horsepower for the supply fan is this value times the Supply Fan Ratio (see above).

Supply Fan Static Pressure

Applicability	All fan systems using the static pressure method
Definition	The design static pressure for the supply fan. This is important for both fan electric energy usage and duct heat gain calculations.
Units	Inches of water column (in. H_20)
Input Restrictions	As designed. The design static pressure for the supply fan does not need to be specified if the supply fan brake horsepower (bhp) is specified.
Standard Design	

The standard design for all systems except four-pipe fan coil (FPFC) and PTAC is defined by the following table:

Airflow	Single Zone, 6 stories or less		Multiple Zone, less than 6 stories	Multiple Zone, greater than 6 stories
<2000 cfm	2.5”		3.0”	3.5”
2000 cfm – 10,000 cfm	3.0”		3.5”	4.0”
>10,000 cfm	3.5”		4.0”	4.5”

An additional pressure drop allowance is available for special filtration requirements only for specific processes such as clean rooms. See *Process and Filtration Pressure Drop* for details.

Not applicable for the four-pipe fan coil system.

Supply Fan Efficiency

Applicability	All fan systems using the static pressure method
Definition	The efficiency of the fan at design conditions; this is the static efficiency and does not include motor losses.
Units	Unitless
Input Restrictions	As designed. The supply fan efficiency does not need to be specified if the supply fan brake horsepower (bhp) is specified.
Standard Design	For all standard design systems except the four-pipe fan coil:

The baseline Supply Fan Efficiency shall be 50% if the design supply air flow is less than 2000 cfm, 60% if the design supply air flow is between 2000 cfm and 10,000 cfm, or 62% if the design supply airflow is greater than 10,000 cfm.

For the four-pipe fan coil system, not applicable.

Supply Motor Efficiency

Applicability	All supply fans, except those specified using the power-per-unit-flow method
Definition	The full-load efficiency of the motor serving the supply fan
Units	Unitless
Input Restrictions	As designed. Not applicable when the power-per-unit-flow method is used.
Standard Design	The motor efficiency is determined from Table 31 for the next motor size greater than the bhp.

Table 31 – Minimum Nominal Efficiency for Electric Motors (%)

Motor Horse Power	
1	85.5
1.5	86.5
2	86.5
3	89.5
5	89.5
7.5	91.7
10	91.7
15	92.4
20	93.0
25	93.6
30	93.6
40	94.1
50	94.5
60	95.0
75	95.4
100	95.4
125	95.4
150	95.8
200	96.2
250	96.2
300	96.2
350	96.2
400	96.2
450	96.2
500	96.2

Fan Position

Applicability	All supply fans
Definition	The position of the supply fan relative to the cooling coil. The configuration is either draw through (fan is downstream of the coil) or blow through (fan is upstream of the coil).
Units	List (see above)

Input Restrictions	As designed.
Standard Design	Draw through

Motor Position

Applicability	All supply fans
Definition	The position of the supply fan motor relative to the cooling air stream. The choices are: in the air stream or out of the air stream.
Units	List (see above)
Input Restrictions	As designed.
Standard Design	In the air stream

Fan Part-Flow Power Curve

Applicability	All variable flow fan systems
Definition	A part-load power curve which represents the percentage full-load power draw of the supply fan as a function of the percentage full-load air flow. The curve is typically represented as a quadratic equation with an absolute minimum power draw specified.
Units	Unitless ratio
Input Restrictions	As designed. The user shall not be able to select VSD with Static Pressure Reset if the building does not have DDC controls to the zone level. The default fan curve shall be selected from Equation (4) and Table 32 for the type of fan specified in the proposed design.

$$\begin{aligned}&Greater\ \ of\\&PLR = a + b \cdot FanRatio + c \cdot FanRatio^2 + d \cdot FanRatio^3\\&PLR = PowerMin\end{aligned} \tag{4}$$

Where:

PLR	Ratio of fan power at part load conditions to full load fan power
PowerMin	Minimum fan power ratio
FanRatio	Ratio of cfm at part-load to full-load cfm
a, b, c and d	Constants from Table 32 below

Table 32 – Fan Curve Default Values

Fan Type - Control Type	a	b	c	d	$\%Power_{Min}$
AF or BI riding the curve[a]	0.1631	1.5901	-0.8817	0.1281	70%
AF or BI with inlet vanes or discharge dampers[a]	0.9977	-0.659	0.9547	-0.2936	50%
FC riding the curve[a]	0.1224	0.612	0.5983	-0.3334	50%
FC with inlet vanes[a]	0.3038	-0.7608	2.2729	-0.8169	50%
Vane-axial with variable pitch blades[a]	0.1639	-0.4016	1.9909	-0.7541	40%
Any fan with VSD	0.070428852	0.385330201	-0.460864118	1.00920344	10%
VSD with static pressure reset	0.040759894	0.08804497	-0.07292612	0.943739823	10%

Data Sources:
a. Advanced VAV System Design Guide, California Energy Commission, CEC Publication 500,-03-082 A-11, 2007.

Standard Design Not applicable for baseline building systems constant volume systems. The curve *VSD with static pressure reset* fans shall be used for variable volume systems.

Supply Fan Power Index

Applicability Fan systems that use the power-per-unit-flow method

Definition The supply fan power (at the motor) per unit of flow.

Units W/cfm

Input Restrictions As designed or specified in the manufacturers' literature. May only be used for four-pipe fan coil systems.

Standard Design For FPFC systems, 0.35 W/cfm; for other systems, not applicable

Process and Filtration Pressure Drop

Applicability Any system with special requirements for filtration or other process requirements

Definition Additional system pressure drop related to application-specific filtration requirements or other process requirements. Special documentation requirements may apply.

Units List

Input Restrictions As designed. Default is 0. Special documentation is required to claim any credit for filtration in excess of 1" w.g. Filtration shall be associated with process requirements (such as clean room or hospital areas).

Standard Design Same as proposed, but subject to a maximum of 1" w.g.

5.7.3.3 Return/Relief Fans

The baseline building has no return fan. The standard design system has a relief fan only if the standard design system has an economizer.

Plenum Zone

Applicability Any system with return ducts or return air plenum

Definition A reference to the thermal zone that serves as return plenum or where the return ducts are located

Units Text, unique

Input Restrictions	As designed
Standard Design	Not applicable

Return Air Path

Applicability	Any system with return ducts or return air plenum
Definition	Describes the return path for air. This can be one of the following: ducted return; plenum return; or direct-to-unit.
Units	List (see above)
Input Restrictions	As designed
Standard Design	Applicable when the baseline building has a relief fan. For baseline building systems 1 and 2, the return air path shall be direct-to-unit. For baseline building systems 3 through 11 the baseline building shall be ducted return.

Return/Relief Fan Design Airflow

Applicability	All systems with a return or relief fan
Definition	The design air flow fan capacity of the return or relief fan(s). This sets the 100% fan flow point for the part-load curve (see below).
Units	cfm
Input Restrictions	As designed For relief fans, the Return/Relief Fan Design Airflow is set equal to the Proposed Design outside air ventilation rate minus the Proposed Design Exhaust Fan Design Airflow and minus 0.05 cfm/ft^2 for pressurization.
Standard Design	The Relief Design Airflow is equal to the design outside airflow minus the exhaust design air flow rate and minus 0.05 cfm/ft^2 for pressurization.

Return/Relief Fan Brake Horsepower

Applicability	Any system with return or relief fans that uses the brake horsepower method
Definition	The design shaft brake horsepower of the return/relief fan(s)
Units	Brake horsepower (bhp)
Input Restrictions	As designed.

The compliance software shall apply the following pre-processing rule to specify the proposed design Return/Relief Fan Brake Horsepower, based on user input:

A Standard Motor Size table (hp) is defined as: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200

The return/relief fan brake horsepower is determined from user inputs of brake horsepower and motor horsepower for the proposed design, in the same manner as the Supply Fan Brake Horsepower.

Proposed bhp = min (user bhp, 95% x $MHPi_{-1}$)

Where:

> proposed bhp is the Return/Relief Fan Brake Horsepower used in the simulation,
>
> User bhp is the actual fan bhp as entered by the user, and

MHP_{i-1} is the motor horsepower of the next smaller motor size from the Standard Motor Size Table above; MHP_i is the motor size that the user enters for the return/relief fan

See the *Supply Fan Brake Horsepower* descriptor for further details.

Standard Design Standard Design systems with an economizer shall use relief fans and shall use the static pressure and fan efficiency method.

Return/Relief Fan Motor Horsepower

Applicability All fan systems, except those specified using the power-per-unit-flow method

Definition The motor nameplate horsepower of the supply fan

Units List: chosen from a list of standard motor sizes: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200

Input Restrictions As designed. This building descriptor is required for the static pressure or the brake horsepower methods

Standard Design The brake horsepower for the supply fan is this value times the Supply Fan Ratio (see above).

Return/Relief Design Static Pressure

Applicability Any system with return or relief fans that uses the static pressure method

Definition The design static pressure for return fan system. This is important for both fan electric energy usage and duct heat gain calculations.

Units Inches of water column (in. H_20 gauge)

Input Restrictions As designed. The design static pressure for the return fan does not need to be specified if the return fan brake horsepower (bhp) is specified.

Standard Design For fans with design airflow less than 10,000 cfm, the static pressure is 0.75”.

For fans with design airflow rate 10,000 cfm or greater, the static pressure is 1.0”

Return/Relief Fan Efficiency

Applicability Any system with return or relief fans that uses the static pressure method

Definition The efficiency of the fan at design conditions; this is the static efficiency and does not include the efficiency loss of the motor.

Units Unitless

Input Restrictions As designed. The return/relief fan efficiency does not need to be specified if the return fan brake horsepower (bhp) is specified.

Standard Design For design airflow less than 10,000 cfm, 40%. For design airflow 10,000 cfm or greater, 50%.

Return/Relief Motor Efficiency

Applicability All return fans, except those specified using the power-per-unit-flow method

Definition

	The full-load efficiency of the motor serving the supply fan
Units	Unitless
Input Restrictions	As designed. Not applicable when the power-per-unit-flow method is used.
Standard Design	From ACM Table 31

Motor Position	
Applicability	All return fans
Definition	The position of the supply fan motor relative to the cooling air stream. The choices are: in the air stream or out of the air stream.
Units	List (see above)
Input Restrictions	As designed.
Standard Design	In the air stream

Fan Part-Flow Power Curve	
Applicability	All return fans for variable flow fan systems.
Definition	A part-load power curve which represents the percentage full-load power draw of the supply fan as a function of the percentage full-load air flow.
Units	Unitless ratio
Input Restrictions	As designed. The default fan curve shall be selected from Equation (4) and Table 32 for the type of fan specified in the proposed design.
Standard Design	Not applicable for baseline building systems 1-4. The curve for VSD fans shall be used for baseline building systems that have a return/relief fan.

5.7.3.4 Exhaust Fan Systems

The Standard Design shall track the Proposed Design exempt process exhaust flow rate up to the prescribed outside air ventilation rate by space type (see Appendix 5.4A for the baseline maximum exhaust rate). Exempt process exhaust includes exhaust from toilets, break rooms, and copy rooms and kitchens. Covered process exhaust includes garage ventilation, lab exhaust and exhaust from kitchens with over 5,000 cfm of exhaust. Rules for the baseline covered process exhaust rate and fan power are discussed in the following sections.

Exhaust fan flow is specified and scheduled for each thermal zone. An exhaust fan system may serve multiple thermal zones. For the standard design, total outside air ventilation supply airflow may need to be adjusted so that the design supply airflow for each floor of the building matches the total design exhaust airflow for that floor.

Exhaust Fan Name	
Applicability	All exhaust systems serving multiple thermal zones
Definition	A unique descriptor for each exhaust fan. This should be keyed to the construction documents, if possible, to facilitate plan checking. Exhaust rates and schedules at the thermal zone level refer to this name.
Units	Text, unique
Input Restrictions	Where applicable, this should match the tags that are used on the plans.

Standard Design	The baseline building will have an exhaust system that corresponds to the proposed design. The name can be identical to that used for the proposed design or some other appropriate name may be used.

Exhaust Fan System Modeling Method

Applicability	All exhaust fan systems
Definition	Compliance software can model fans in three ways. See definition for supply system modeling method.
Units	List: power-per-unit-flow, static pressure or brake horsepower
Input Restrictions	As designed
Standard Design	The baseline building shall use the static pressure method.

Exhaust Fan Design Airflow

Applicability	All exhaust systems
Definition	The rated design air flow rate of the exhaust fan system. This building descriptor defines the 100% flow point of the part-flow curve. Actual air flow is the sum of the flow specified for each thermal zone, as modified by the schedule for each thermal zone.
Units	cfm
Input Restrictions	As designed. The total design exhaust flow capacity for building (conditioned space) shall not exceed the sum of building minimum ventilation (outdoor) air flow. That is, exhaust makeup can be transferred from other zones in the building provided that the total building exhaust rate does not exceed the total minimum outside air flow rate.
Standard Design	Same as proposed design, but with the same limitations described under Input Restrictions. The design supply air ventilation rate for zone(s) may need to be adjusted by the software, so that the total design outside air ventilation rate supplied to all zones on a floor equals the total exhaust fan design airflow for all zones on the floor.

Exhaust Fan Control Method

Applicability All exhaust fan systems

Definition A description of how the exhaust fan(s) are controlled. The options include:

- Constant volume
- Variable-flow, variable speed drive (VSD)
- Variable-flow, constant speed

Units List (see above)

Input Restrictions As designed, however, when exhaust fan flow at the thermal zone level is varied through a schedule, one of the variable-flow options shall be specified.

Standard Design The baseline building exhaust fan control shall be the same as the proposed design, but subject the conditions described above.

For exhaust fans serving kitchen spaces, the fan control method is constant volume for fans with flow rate 5,000 cfm and below, and variable flow, variable speed drive for fans with flow rate greater than 5,000 cfm.

For exhaust fans serving Laboratory spaces, the fan control method is variable-flow, variable speed drive when the exhaust flow exceeds 2,000 cfm and 10 ACH. If the lab exhaust flow does not meet both of these conditions, the standard design is constant flow.

Exhaust Fan Schedule

Applicability	All exhaust fan systems
Definition	A schedule that indicates when the exhaust fan system is available for operation. Exhaust fan flow is specified at the thermal zone level.
Units	Data structure: schedule, on/off
Input Restrictions	For exhaust fans not serving kitchen and lab spaces, the schedule is fixed to match the HVAC availability schedule for the specified occupancy in Appendix 5.4B. For kitchen and la spaces, the schedule is defined in Appendix 5.4B.
Standard Design	Specified in Appendix 5.4B for the specified occupancy.

Exhaust Fan Brake Horsepower

Applicability All exhaust fan systems

Definition The design shaft brake horsepower of the exhaust fan(s).

Units Brake horsepower (bhp)

Input Restrictions As designed

Standard Design The Compliance Software implements a pre-processing rule to specify the proposed design Exhaust Fan Brake Horsepower (bhp), based on user input:

A Standard Motor Size table (hp) is defined as: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200

The exhaust fan brake horsepower is determined from user inputs of brake horsepower and motor horsepower for the proposed design, in the same manner as the Supply Fan Brake Horsepower.

Proposed bhp = max (user bhp, 95% x $MHPi_{-1}$)

Where Proposed bhp is the Return/Relief Fan Brake Horsepower used in the simulation,

User bhp is the actual fan bhp as entered by the user, and

MHP_{i-1} is the motor horsepower of the next smaller motor size from the Standard Motor Size Table above; MHP_i is the motor size that the user enters for the exhaust fan

See the *Supply Fan Brake Horsepower* descriptor for further details.

Exhaust Fan Motor Horsepower

Applicability	All fan systems, except those specified using the power-per-unit-flow method
Definition	The motor nameplate horsepower of the supply fan
Units	List: chosen from a list of standard motor sizes: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200
Input Restrictions	As designed. This building descriptor is required for the static pressure or the brake horsepower methods
Standard Design	Not applicable.

Exhaust Fan Design Static Pressure	
Applicability	Any system with return or relief fans that uses the static pressure method
Definition	The design static pressure for exhaust fan system. This is important for both fan electric energy usage and duct heat gain calculations.
Units	Inches of water column (in. H_20)
Input Restrictions	As designed for exhaust fans not serving kitchens. The design static pressure for the exhaust fan does not need to be specified if the exhaust fan brake horsepower (bhp) is specified.
Standard Design	For kitchen exhaust fans, the static pressure is fixed at 2.5" w.c. For lab exhaust, 4" if 6 stories or less, or 4.5" if greater than 6 stories. For all other exhaust fans, the standard design fan W/cfm shall be the same as the proposed design W/cfm.

Exhaust Fan Efficiency	
Applicability	Any exhaust fan system that uses the static pressure method
Definition	The efficiency of the exhaust fan at rated capacity; this is the static efficiency and does not include losses through the motor.
Units	Unitless
Input Restrictions	For kitchen exhaust fans, the fan efficiency is prescribed at 50%. For all other exhaust fans, as designed. The exhaust fan efficiency does not need to be specified if the return fan brake horsepower (bhp) is specified.
Standard Design	For kitchen exhaust fans, the fan efficiency is 50%. For lab exhaust: 62% For all other exhaust fans, the standard design efficiency (and resulting W/cfm) shall be the same as the proposed design efficiency (and resulting W/cfm).

Exhaust Fan Motor Efficiency	
Applicability	All exhaust fan systems
Definition	The full-load efficiency of the motor serving the exhaust fan
Units	Unitless
Input Restrictions	As designed
Standard Design	For exempt process fans other than lab, kitchen and garage exhaust fans, same as proposed. For process fans, value is taken; otherwise, from Table 32

Fan Part-Flow Power Curve	
Applicability	All variable flow exhaust fan systems
Definition	A part-load power curve which represents the ratio full-load power draw of the exhaust fan as a function of the ratio full-load air flow.
Units	Unitless ratio
Input Restrictions	

	As designed. The default fan curve shall be selected from Equation (4) and Table 32 for the type of fan specified in the proposed design.
Standard Design	The baseline building fan curve shall be selected from Equation (4) and Table 32 for the type of fan specified in the proposed design.

Exhaust Fan Power Index

Applicability	All exhaust systems serving high-rise residential units and hotel/motel guestrooms
Definition	The fan power of the exhaust fan per unit of flow. This building descriptor is applicable only with the power-per-unit-flow method.
Units	kW/cfm
Input Restrictions	As designed.
Standard Design	For high-rise residential units and hotel/motel guestrooms, 0.58 W/cfm

5.7.3.5 Garage Exhaust Fan Systems

Garage exhaust fan systems shall be modeled and included as part of regulated building energy use. These fans shall be modeled as constant volume fans, with the fan power determined by whether or not the fan has CO controls.

Garage Exhaust Fan Name

Applicability	All garage exhaust systems
Definition	A unique descriptor for each garage exhaust fan or fan system. Fans with equivalent efficiency and motor efficiencies may be combined and modeled as one fan.
Units	Text, unique
Input Restrictions	Where applicable, this should match the tags that are used on the plans.
Standard Design	The baseline building will have an exhaust system that corresponds to the proposed design. The name can be identical to that used for the proposed design or some other appropriate name may be used.

Garage Exhaust Fan System Modeling Method

Applicability	All exhaust fan systems
Definition	Software commonly models fans in three ways. See definition for supply system modeling method.
Units	List: power-per-unit-flow, static pressure or brake horsepower
Input Restrictions	brake horsepower method (fixed value)
Standard Design	The baseline building shall use the power-per-unit-flow method.

Garage Exhaust Fan Rated Capacity

Applicability	All exhaust systems
Definition	The rated design air flow rate of the garage exhaust fan system.
Units	cfm
Input Restrictions	As designed
Standard Design	Same as proposed design

Garage Exhaust Fan Control Method	
Applicability	All exhaust fan systems
Definition	The control method for the garage exhaust fan. This input determines the fan power for the exhaust fan; no other fan inputs are required.
Units	List: Constant Volume, CO Control
Input Restrictions	For systems with fan capacity below 10,000 cfm, either *Constant Volume or CO Control* For systems with fan capacity above 10,000 cfm, *CO Control* If *Constant Volume* is selected, proposed fan power is as designed If *CO Control* is selected, proposed fan power is 12.5% of the design fan power
Standard Design	For garage fans with a supply air flowrate below 10,000 cfm, the baseline fan power is 0.35 W/cfm. For garage fans with a design supply air flowrate of 10,000 cfm and above, the baseline fan power is 0.044 W/cfm.

5.7.3.6 Duct Systems in Unconditioned Space

Duct Leakage Adjustment Factor	
Applicability	Any single-zone, constant volume systems with ducts in unconditioned space serving zones of 5,000 ft^2 or less.
Definition	An fan efficiency adjustment factor to account for the leakage rate from the duct system into unconditioned space.
Units	Unitless fraction
Input Restrictions	For new systems: If duct leakage testing is passes required leakage rates with HERS testing defined in Reference Appendix NA2, 1. If not tested or if the duct system fails the leakage test, 0.769. For existing, altered systems: 15% if tested and verified by the HERS procedures in Reference Appendix NA2. If untested or if failed test, 20%.
Standard Design	**1** for new construction 15% for existing, altered systems

Duct Location	
Applicability	Single zone, constant volume systems with ducts in unconditioned space, serving less than 5000 ft2 of floor area
Definition	The duct location: fraction that is in unconditioned space, is in conditioned space, and is outdoors
Units	three unitless fractions
Input Restrictions	all in unconditioned space
Standard Design	all in unconditioned space

5.7.4 Outdoor Air Controls and Economizers

5.7.4.1 Outside Air Controls

Maximum Outside Air Ratio

Applicability	All systems with modulating outside air dampers
Definition	The descriptor is used to limit the maximum amount of outside air that a system can provide as a percentage of the design supply air. It is used where the installation has a restricted intake capacity.
Units	Ratio
Input Restrictions	For systems with capacity under 54,000 Btu/h without FDD, the maximum allowed value is 0.9. For all other systems the maximum allowed value is 1.
Standard Design	1.0 for all systems above 54,000 Btu/h cooling capacity; 0.9 for other systems

Design Outside Air Flow

Applicability	All systems with outside air dampers
Definition	The rate of outside air that needs to be delivered by the system at design conditions. This input may be derived from the sum of the design outside air flow for each of the zones served by the system.
Units	cfm
Input Restrictions	As designed, but no lower than the ventilation rate of the standard design.
Standard Design	Minimum ventilation requirements specified by Standard 120(b)2 as the greater of 15 cfm/person and the minimum ventilation rates specified in Appendix 5.4 For systems serving laboratory spaces, the system shall be 100% outside air, with ventilation rates as specified by the user, but not less than 6 ACH. See *ventilation control method* at the zone level.

Outdoor Air Control Method

Applicability	All HVAC systems that deliver outside air to zones
Definition	The method of determining the amount of outside air that needs to be delivered by the system. Each of the zones served by the system report their outside air requirements on an hourly basis. The options for determining the outside air at the zone level are discussed above. This control method addresses how the system responds to this information on an hourly basis. Options include: • Average Flow. The outside air delivered by the system is the sum of the outside air requirement for each zone, without taking into account the position of the VAV damper in each zone. The assumption is that there is mixing between zones through the return air path. • Critical Zone. The critical zone is the zone with the highest ratio of outside air to supply air. The assumption is that there is no mixing between zones. This method will provide greater outside air than the average flow method because when the

critical zone sets the outside air fraction at the system, the other zones are getting greater outside air than required.

Units List (see above)

Input Restrictions As designed

Standard Design Average Flow

5.7.4.2 Air Side Economizers

Economizer Control Type

Applicability All systems with an air-side economizer

Definition An air-side economizer increases outside air ventilation during periods when refrigeration loads can be reduced from increased outside air flow. The control types include:

- No economizer
- Fixed dry-bulb. The economizer is enabled when the temperature of the outside air is equal to or lower than temperature fixed setpoint (e.g., 75F).
- Differential dry-bulb. The economizer is enabled when the temperature of the outside air is lower than the return air temperature.
- Differential enthalpy. The economizer is enabled when the enthalpy of the outside air is lower than the return air enthalpy.
- Differential dry-bulb and enthalpy. The system shifts to 100% outside air, or the maximum outside air position needed to maintain the cooling SAT setpoint, when the outside air dry-bulb is less than the return air dry-bulb AND the outside air enthalpy is less than the return air enthalpy. This control option requires additional sensors.
- Fixed or dry-bulb enthalpy. The economizer is enabled when the outside air dry-bulb and enthalpy are both below the fixed setpoints for the return air.
- Fixed dewpoint and dry-bulb. The system shifts to 100% outside air, or the maximum outside air position needed to maintain the SAT setpoint, when the dewpoint of the air and dry-bulb are below the specified setpoints.

Units List (see above)

Input Restrictions As designed

Standard Design The control should be no economizer when the baseline cooling capacity <u>< 54,000 Btu/h and when the standard design cooling system is NOT a computer room air handling unit (CRAH). Otherwise the baseline building shall assume an integrated differential dry-bulb economizer.</u>

An exception is that economizers shall NOT be modeled for systems serving high-rise residential or hotel/motel guestroom occupancies.

Economizer Integration Level

Applicability Airside economizers

Definition This input specifies whether or not the economizer is integrated with mechanical cooling. It is up to the modeling software to translate this into software-specific inputs to model this feature. The input could take the following values:

- Non-integrated. The system runs the economizer as the first stage of cooling. When the economizer is unable to meet the load, the economizer returns the outside air damper to the minimum position and the compressor turns on as the second stage of cooling.
- Integrated. The system can operate with the economizer fully open to outside air and mechanical cooling active (compressor running) simultaneously, even on the lowest cooling stage.

Units	List
Input Restrictions	List: Non-integrated, Integrated
Standard Design	Integrated for systems above capacity 54,000 Btu/h at AHRI conditions

Economizer High Temperature Lockout

Applicability	Systems with *fixed dry-bulb* economizer
Definition	It is the outside air setpoint temperature above which the economizer will return to minimum position.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	Not applicable

Economizer Low Temperature Lockout

Applicability	Systems with air-side economizers
Definition	A feature that permits the lockout of economizer operation (return to minimum outside air position) when the outside air temperature is below the lockout setpoint.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	Not used

Economizer High Enthalpy Lockout

Applicability	Systems with differential enthalpy economizers
Definition	The outside air enthalpy above which the economizer will return to minimum position
Units	Btu/lb
Input Restrictions	As designed. The default is 28 Btu/lb. (High altitude locations may require different setpoints.) The compliance software shall apply a fixed offset and add 2 Btu/lb to the user-entered value.
Standard Design	No lockout limit

5.7.5 Cooling Systems

5.7.5.1 General

This group of building descriptors applies to all cooling systems.

Cooling Source

Applicability	All systems
Definition	The source of cooling for the system. The choices are: • Chilled water • Direct expansion (DX) • Other
Units	List (see above)
Input Restrictions	As designed
Standard Design	The baseline building cooling source is shown in Table 33.

Table 33 – Cooling Source for Baseline Building System

Baseline building System	Cooling Source
System 1 – PTAC	Direct expansion (DX)
System 2 – FPFC	Chilled water
System 3 – PSZ-AC	Direct expansion (DX)
System 5 – Packaged VAV with Reheat	Direct expansion (DX)
System 6 – VAV with Reheat	Chilled water
System 7 – PSZ, Single Zone VAV	Direct expansion (DX)
System 9 – Heating and Ventilation	None
System 10 – CRAH Unit for Data Centers	Chilled water
System 11 – CRAC Unit for Data Centers	Direct expansion (DX)

Gross Total Cooling Capacity

Applicability All cooling systems

Definition The total gross cooling capacity (both sensible and latent) of a cooling coil or packaged DX system at AHRI conditions. The building descriptors defined in this chapter assume that the fan is modeled separately, including any heat it adds to the air stream. The cooling capacity specified by this building descriptor should not consider the heat of the fan.

Units Btu/h

Input Restrictions NOT A USER INPUT.

For packaged equipment that has the fan motor in the air stream such that it adds heat to the cooled air, the software shall calculate the net *total cooling capacity* as follows:

$$Q_{t,net,rated} = Q_{t,gross,rated} - Q_{fan,rated} \qquad (6)$$

where

$Q_{t,net,rated}$ The net total cooling capacity of a packaged unit as rated by AHRI (Btu/h)

$Q_{t,gross,rated}$ The AHRI rated total cooling capacity of a packaged unit (Btu/h)
Qfan,rated The heat generated by the fan and fan motor (if fan motor is in airstream) at AHRI rated conditions

If the gross and net total cooling capacities at AHRI conditions are known, the fan heat at rated conditions is the difference between the two values. If the either the gross or net total cooling capacity is unknown, the fan heat at rated conditions shall be accounted for by using equation (7):

$$Q_{fan,rated} = Q_{t,gross,rated} \times 0.0415 \qquad (7)$$

This equation 7 is based on an AHRI rated fan power of 0.365 W/cfm, and a cooling airflow of 400 cfm/ton.

If the number of unmet load hours in the proposed design exceeds 150, the software shall warn the user to resize the equipment.

Standard Design The gross total cooling capacity of the systems in the baseline building is determined from the standard design net cooling capacity, and from applying the fan power rules above for adjusting for fan heat.

Gross Sensible Cooling Capacity

Applicability All cooling systems

Definition The gross sensible cooling capacity of the coil or packaged equipment at AHRI conditions. The building descriptors defined in this chapter assume that the fan is modeled separately, including any heat it adds to the air stream. The cooling capacity specified by this building descriptor should be adjusted to calculate the net sensible cooling capacity, which includes the effect of fan motor heat.

Note that the sensible heat ratio (SHR) used by some energy simulation tools can be calculated from the sensible cooling capacity and total cooling capacity:

SHR = Sensible Cooling Capacity / Total Cooling Capacity

Units Btu/h

Input Restrictions As designed.

For packaged equipment, the compliance software adjusts the user input of gross sensible cooling capacity to account for the effect of fan motor heat as follows:

$$Q_{s,net,rated} = Q_{s,gross,rated} - Q_{fan,rated} \qquad (8)$$

Where:

$Q_{s,net,rated}$	The AHRI rated (from manufacturers' literature) or net sensible cooling capacity of a packaged unit (Btu/h)
$Q_{s,gross,rated}$	The AHRI rated (from manufacturers' literature) or gross sensible cooling capacity of a packaged unit (Btu/h)
$Q_{fan,rated}$	The heat generated by the fan and fan motor (if fan motor is in air stream) at AHRI rated or hourly conditions (Btu/h). See Gross Total Cooling Capacity building descriptor.

If the number of unmet load hours in the proposed design exceeds 150, the software shall warn the user to resize the equipment.

Standard Design The gross total cooling capacity of the systems serving the baseline building is autosized by the compliance software, and then oversized by 15%. Sizing calculations shall be based on 0.5% design dry-bulb and mean coincident wet-bulb.

Cooling Capacity Adjustment Curves

Applicability All cooling systems

Definition A curve that represents the available total cooling capacity as a function of cooling coil and/or condenser conditions. The common form of these curves is given as follows:

$$Q_{t,available} = CAP\_FT \times Q_{t,adj} \tag{5}$$

For air cooled direct expansion

$$CAP\_FT = a + b \times t_{wb} + c \times t_{wb}^2 + d \times t_{odb} + e \times t_{odb}^2 + f \times t_{wb} \times t_{odb} \tag{6}$$

For water cooled direct expansion

$$CAP\_FT = a + b \times t_{wb} + c \times t_{wb}^2 + d \times t_{wt} + e \times t_{wt}^2 + f \times t_{wb} \times t_{wt} \tag{7}$$

For chilled water coils

$$CAP\_FT = a + b \times t_{wb} + c \times t_{wb}^2 + d \times t_{db} + e \times t_{db}^2 + f \times t_{wb} \times t_{db} \tag{8}$$

Where:

$Q_{t,available}$	Available cooling capacity at specified evaporator and/or condenser conditions (MBH)
$Q_{t,adj}$	Adjusted capacity at AHRI conditions (Btu/h
CAP_FT	A multiplier to adjust $Q_{t,adj}$
t_{wb}	The entering coil wet-bulb temperature (°F)
t_{db}	The entering coil dry-bulb temperature (°F)
t_{wt}	The water supply temperature (°F)
t_{odb}	The outside-air dry-bulb temperature (°F)

Note: if an air-cooled unit employs an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.

Software may represent the relationship between cooling capacity and temperature in ways other than the equations given above.

Table 34 –Cooling Capacity Curve Coefficients

	Air Cooled Direct Expansion		Water Cooled Direct Expansion		Chilled Water Coils	
Coefficient	Air-Source (PTAC)	Air-Source (Other DX)	Water-Source (Heat Pump)	Water-Source (Other DX)	Fan-Coil	Other Chilled Water
a	1.1839345	0.8740302	-0.2780377	0.9452633	0.5038866	2.5882585
b	-0.0081087	-0.0011416	0.0248307	-0.0094199	-0.0869176	-0.2305879
c	0.0002110	0.0001711	-0.0000095	0.0002270	0.0016847	0.0038359
d	-0.0061435	-0.0029570	-0.0032731	0.0004805	0.0336304	0.1025812
e	0.0000016	0.0000102	0.0000070	-0.0000045	0.0002478	0.0005984
f	-0.0000030	-0.0000592	-0.0000272	-0.0000599	-0.0010297	-0.0028721

Note: These curves are the DOE-2.1E defaults, except for Water-Source (Other DX), which is taken from the "ECB Compliance Supplement, public review draft prepared by the SSPC 90.1 ECB Panel, Version 1.2, March 1996.

Units Data structure

Input Restrictions As designed. The equations and coefficients given above are the default.

Standard Design Use the default curves or equivalent data for other models.

Coil Latent Modeling Method

Applicability All DX cooling systems

Definition The method of modeling coil latent performance at part-load conditions.

Units List

Input Restrictions One of the following values:

Bypass factor – used by DOE-2 based programs

NTU-effectiveness – used by EnergyPlus

Standard Design Same as proposed

Coil Bypass Factor

Applicability All DX cooling systems using the *bypass factor* Coil Latent Modeling Method

Definition The ratio of air that bypasses the cooling coil at design conditions to the total system airflow.

Units Ratio

Input Restrictions Prescribed values as shown in Table 35.

Table 35 – Default Coil Bypass Factors

System Type	Default Bypass Factor
o Packaged Terminal Air-conditioners and Heat Pumps	o 0.241
o Other Packaged Equipment	o 0.190
o Multi-Zone Systems	o 0.078
o All Other	o 0.037

Standard Design Defaults

Coil Bypass Factor Adjustment Curve

Applicability	All DX cooling systems using the *bypass factor* Coil Latent Modeling Method
Definition	Adjustments for the amount of coil bypass due to the following factors:

- Coil airflow rate as a percentage of rated system airflow
- Entering air wet-bulb temperature
- Entering air dry-bulb temperature
- Part load ratio

Units	Data structure
Input Restrictions	Where applicable, prescribed (fixed) simulation engine defaults based on HVAC system type. The following default values shall be used for the adjustment curves:

$$CBF_{adj} = CBF_{rated} \times COIL - BF - FFLOW \times COIL - BF - FT \times COIL - BF - FPLR \tag{9}$$

$$\text{COIL-BF-FFLOW} = a + b \times CFMR + c \times CFMR^2 + d \times CFMR^3 \tag{10}$$

$$\text{COIL-BF-FT} = a + b \times T_{wb} + c \times T_{wb}{}^2 + d \times T_{db} + e \times T_{db}{}^2 + f \times T_{wb} \times T_{db} \tag{11}$$

$$COIL - BF - FPLR = a + b \times PLR \tag{12}$$

Where:

CBF_{rated}	The coil bypass factor at AHRI rating conditions
CBF_{adj}	The coil bypass factor adjusted for airflow and coil conditions
CFMR	The ratio of airflow to design airflow
COIL-BF-FFLOW	A multiplier on the rated coil bypass factor to account for variation in air flow across the coil (take coefficients from Table 36)
COIL-BF-FT	A multiplier on the rated coil bypass factor to account for a variation in coil entering conditions (take coefficients from Table 37)
COIL-BF-FPLR	A multiplier on the rated coil bypass factor to account for the part load ratio (take coefficients from Table 38)
T_{wb}	The entering coil wet-bulb temperature (°F)
T_{db}	The entering coil dry-bulb temperature (°F)
PLR	Part load ratio

And the coefficients are listed in the tables below.

Table 36 – Coil Bypass Factor Airflow Adjustment Factor

Coefficient	COIL-BF-FFLOW (PTAC)	COIL-BF-FFLOW (HP)	COIL-BF-FFLOW (PSZ/other)
a	-2.277	-0.8281602	-0.2542341
b	5.21140	14.3179150	1.2182558
c	-1.93440	-21.8894405	0.0359784
d		9.3996897	

Table 37 – Coil Bypass Factor Temperature Adjustment Factor

Coefficient	COIL-BF-FT (PTAC)	COIL-BF-FT (HP)	COIL-BF-FT (PSZ, other)
a	-1.5713691	-29.9391098	1.0660053
b	0.0469633	0.8753455	-0.0005170
c	0.0003125	-0.0057055	0.0000567
d	-0.0065347	0.1614450	-0.0129181
e	0.0001105	0.0002907	-0.0000017
f	-0.0003719	-0.0031523	0.0001503

Table 38 – Coil Bypass Factor Part Load Adjustment Factor

Coefficient	COIL-BF-FPLR (All Systems)
a	0.00
b	1.00

Standard Design Use defaults as described above.

Cooling Capacity Airflow Adjustment Curve

Applicability All DX cooling systems using the *NTU Effectiveness* Coil Latent Modeling Method

Definition Normalized curve that varies cooling capacity as a function of airflow, which affects system latent capacity

Units Data structure

Input Restrictions Where applicable, prescribed (fixed) simulation engine defaults based on HVAC system type. The following default values shall be used for the adjustment curves:

(13)

$$CoolCapacity_{adj} = CoolCapacity_{rated} \times COOL-CAP-FFLOW \times COOL-CAP-FT$$

(14)

Where:

CFMR	The ratio of airflow to design airflow
COOL-CAP-FFLOW	A multiplier on the rated coil capacity to account for variation in air flow across the coil (take coefficients from Table 36)
COOL-CAP-FT	A multiplier on the rated coil bypass factor to account for a variation in coil entering conditions (take coefficients from Table 37)

The curve takes the form:

COOL-CAP-FFLOW = a + b x CFMR + c x $CFMR^2$ + d x $CFMR^3$

And the coefficients are listed in the tables below.

Table 39 – Cooling Capacity Airflow Adjustment Factor

Coefficient	COOL-CAP-FFLOW
a	0.47278589
b	1.2433415
c	-1.0387055
d	0.32257813

Standard Design Use defaults as described above.

5.7.5.2 Direct Expansion

Direct Expansion Cooling Efficiency

Applicability Packaged DX equipment

Definition The cooling efficiency of a direct expansion (DX) cooling system at AHRI rated conditions as a ratio of output over input in Btu/h per W, excluding fan energy. The abbreviation used for this full-load efficiency is EER.

For all unitary and applied equipment where the fan energy is part of the equipment efficiency rating, the EER shall be adjusted as follows:

(15)

$$EER_{adj} = \frac{Q_{t,net,rated} + Q_{fan,rated}}{\frac{Q_{t,net,rated}}{EER} - \frac{Q_{fan,rated}}{3.413}}$$

Where:

EER_{adj}	The adjusted *Energy Efficiency Ratio* for simulation purposes
EER	The rated Energy Efficiency Ratio
$Q_{t,gross,rated}$	The AHRI rated total gross cooling capacity of a packaged unit (kBtu/h)
Qfan,rated	The AHRI rated fan energy, specified in equation (7) for the Gross Total Cooling Capacity building descriptor

Units Btu/h-W

Input Restrictions As designed, except that the user-entered value must meet mandatory minimum requirements of Table 110.2-A, Table 110.2-B or Table 110.2-C for the applicable equipment type. When possible, specify the SEER and EER for packaged equipment with cooling capacity less than 65,000 Btu/h from manufacturer's literature. For equipment with capacity above 65,000 Btu/h, specify EER.

When EER is not available for packaged equipment with SEER ratings (AHRI cooling capacity of 65,000 Btu/h or smaller), it shall be calculated as follows:

(16)

$$EER = MIN(-0.0194 \times SEER^2 + 1.0864 \times SEER, 13)$$

The default EER shall be calculated by the equation above, but constrained to be no greater than 13.

Evaporative cooling systems that pass the requirements of the Western Cooling Challenge may be modeled with an EER as if the equipment were packaged unitary equipment. See section 5.7.5.4.

Standard Design Use the minimum cooling efficiency (EER) from tables in Tables 110.2-A, 110.2-B and 110.2-E in Section 110.2 of the Standard.

Seasonal Energy Efficiency Ratio

Applicability Packaged DX equipment with AHRI cooling capacity of 65,000 Btu/h or smaller

Definition The seasonal cooling efficiency of a direct expansion (DX) cooling system at AHRI rated conditions as a ratio of output over input in Btu/h per W, excluding fan energy. The software must accommodate user input in terms of either the *Energy Efficiency Ratio (*EER) or the *Seasonal Energy Efficiency Ratio* (SEER). For equipment with SEER ratings, EER shall be taken from manufacturers' data when it is available.

Units Btu/h-W

Input Restrictions As designed. This input is required for small DX systems. The Direct Expansion Cooling Efficiency input is optional for these systems.

Standard Design Use the minimum SEER from the 2009 Appliance Efficiency Standards.

Integrated Energy Efficiency Ratio

Applicability Packaged DX equipment with AHRI cooling capacity of 65,000 Btu/h or greater

Definition Integrated Energy Efficiency Ratio. This is a seasonal energy efficiency ratio that is a composite rating for a range of part-load conditions and different ambient conditions. The rating is determined according to AHRI procedures, and equipment with this rating is subject to mandatory minimum requirements.

This input is currently only used for mandatory minimum efficiency checks.

Units Btu/h-W

Input Restrictions As designed. If the IEER rating is below mandatory minimum required levels specified in Section 110.2 of the Standards, the compliance run shall fail.

Standard Design Not applicable

Direct Expansion Cooling Efficiency Temperature Adjustment Curve

Applicability Packaged DX equipment

Definition

A curve that varies the cooling efficiency of a direct expansion (DX) coil as a function of evaporator conditions, condenser conditions, and for small packaged equipment, part-load ratio.

(17)

For air-cooled DX systems:

$$EIR\_FT = a + b \times t_{wb} + c \times t_{wb}^{2} + d \times t_{odb} + e \times t_{odb}^{2} + f \times t_{wb} \times t_{odb}$$

(18)

For water-cooled DX systems:

$$EIR\_FT = a + b \times t_{wb} + c \times t_{wb}^{2} + d \times t_{wt} + e \times t_{wt}^{2} + f \times t_{wb} \times t_{wt}$$

(19)

$$P_{operating} = P_{rated} \times EIR\_FPLR \times EIR\_FT \times CAP\_FT$$

Where:

PLR	Part load ratio based on available capacity (not rated capacity)
EIR-FT	A multiplier on the EIR to account for the wet-bulb temperature entering the coil and the outdoor dry-bulb temperature
$Q_{operating}$	Present load on heat pump (Btu/h)
$Q_{available}$	Heat pump available capacity at present evaporator and condenser conditions (in Btu/h).
t_{wb}	The entering coil wet-bulb temperature (°F)
t_{wt}	The water supply temperature (°F)
t_{odb}	The outside-air dry-bulb temperature (°F)
P_{rated}	Rated power draw at AHRI conditions (kW)
$P_{operating}$	Power draw at specified operating conditions (kW)

Note: if an air-cooled unit employs an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.

Table 40 – Cooling System Coefficients for EIR-FT

Coefficient	Water-Source (Heat Pump)	Water-Source (Other)	Air-Source (PTAC)	Air-Source (PSZ with Cool Cap <=65,000 Btu/h)	Air-Source (Other)
a	2.0280385	-1.8394760	-0.6550461	n/a (see Standard Design)	-1.0639310
b	-0.0423091	0.0751363	0.0388910	n/a	0.0306584
c	0.0003054	-0.0005686	-0.0001925	n/a	-0.0001269
d	0.0149672	0.0047090	0.0013046	n/a	0.0154213
e	0.0000244	0.0000901	0.0001352	n/a	0.0000497
f	-0.0001640	-0.0001218	-0.0002247	n/a	-0.0002096

Units Data structure

Input Restrictions User may input curves or use default curves. If defaults are overridden, the software must indicate that supporting documentation is required on the output forms.

For direct-expansion equipment with a capacity greater than 65,000 Btu/h, the user may not enter data on the temperature dependent equipment performance. However, the ACM compliance software vendor may work with manufacturers to collect such data and build this data into the ACM compliance software. The user may either select equipment for which the ACM compliance software vendor has collected or use the defaults.

Standard Design For all systems except packaged DX units with cooling capacity <= 65,000 Btu/h, use default curves from Appendix 5.7. For packaged DX units with cooling capacity less than or equal to 65,000 Btu/h that have SEER ratings, the user inputs EER and SEER, and the software generates the equipment performance curve based on the pre-defined performance curves specified in Appendix 5.7.

Direct Expansion Part-Load Efficiency Adjustment Curve

Applicability Packaged systems with direct expansion (DX) cooling

Definition A normalized performance adjustment curve to the rated efficiency (Energy Input Ratio) that describes how the efficiency varies at part-load conditions. At a value of 1 (full load), the normalized efficiency is 1 (same as part-load conditions).

The default curves are given as follows as adjustments to the energy input ratio (EIR)[8]:

(20)

$$PLR = \frac{Q_{operating}}{Q_{available}\left(t_{wb}, t_{odb/wt}\right)}$$

(21)

$$EIR\_FPLR = a + b \times PLR + c \times PLR^2 + d \times PLR^3$$

$$PLF\_FPLR = a + b \times PLR + c \times PLR^2 + d \times PLR^3$$

This curve may take the form of a part-load factor (PLF) or EIR-FLPR, which is the fraction of time the unit must run to meet the part-load for that hour. For example, at 40% of full load, the equipment might need to run 50% of the hour (for cycling losses).

Note that for small packaged equipment with SEER ratings (<65,000 Btu/h), the part-load efficiency curve is set to no degradation, since the part-load degradation is built-into the *Direct Expansion Cooling Efficiency Temperature Adjustment Curve*.

Default curves are provided for the different major classes of equipment.

Units Coefficients (three for a quadratic, or up to four for a cubic)

Input Restrictions The coefficients should sum to 1 (within a small tolerance). This corresponds to a curve output of 1 for an input of 1.

Standard Design

8 The EIR is the ratio of energy used by the system to cooling capacity in the same units. It is the reciprocal of the coefficient of performance (COP). EnergyPlus uses a part-load factor correlation for PLF as a function of PLR. The EnergyPlus PLF is related to the DOE-2 EIR(PLR) by the following: EIR-FPLR = PLR / PLF.

The baseline part-load efficiency adjustment curves are shown in the tables below.

Table 41 – Cooling System Coefficients for EIR-FPLR

Coefficient	Water-Source (Heat Pump)	Water-Source (Other)	Air-Source (PTAC)	Air-Source (PSZ with Cap<65,000 Btu/h)	Air-Source (Other)
a	0.1250000	0.2012301	0.1250000	0	0.2012301
b	0.8750000	-0.0312175	0.8750000	1	-0.0312175
c	0.0000000	1.9504979	0.0000000	0	1.9504979
d	0.0000000	-1.1205105	0.0000000	0	-1.1205105

Table 42 – Cooling System Coefficients for Part-Load Factor (PLF) Correlation (EnergyPlus)

Coefficient	Water-Source (Heat Pump)	Water-Source (Other)	Air-Source (PTAC)	Air-Source (PSZ with Cap<65,000 Btu/h)	Air-Source (Other)
a	0.85	0	0.85	1	0
b	0.15	5.1091	0.15	0	5.1091
c	0	-8.5515	0	0	-8.5515
d	0	4.4744	0	0	4.4744

Number of Cooling Stages

Applicability	Single Zone VAV Systems and DX systems with multiple stages
Definition	This applies to Single Zone VAV and any HVAC systems with multiple compressors or multiple discrete stages of cooling. This system is a packaged unit with multiple compressors and a two-speed or variable-speed fan. Systems with unequally sized compressors may have additional cooling stages.
Units	None (Integer)
Input Restrictions	As Designed
Standard Design	The standard design shall be 2 for the Single Zone VAV baseline and packaged VAV baseline.

Total Cooling Capacity by Stage

Applicability	Single Zone VAV Systems and DX systems with multiple stages
Definition	This provides the total cooling capacity of each cooling stage, at AHRI rated conditions. The capacity is expressed as an array, with each entry a fraction of the total rated cooling capacity for the unit. For example, if the stage cooling capacity is 4 tons (48,000 Btu/h) and the total cooling capacity is 8 tons (96,000 Btu/h), the capacity is expressed as “0.50” for that stage.
Units	Array of fractions
Input Restrictions	As Designed
Standard Design	The default shall be (0.50, 1) for the Single Zone VAV baseline.

Sensible Cooling Capacity by Stage

Applicability	Single Zone VAV Systems and DX systems with multiple stages
Definition	This provides the sensible cooling capacity of each cooling stage, at AHRI rated conditions. The capacity is expressed as an array, with each entry a fraction of the total rated sensible cooling capacity for the unit. For example, if the stage sensible

cooling capacity is 3.5 tons (42,000 Btu/h) and the total sensible cooling capacity is 7 tons (72,000 Btu/h), the capacity is expressed as "0.5" for that stage."

Units	Array of fractions
Input Restrictions	As Designed
Standard Design	The default shall be (0.50, 1) for the Single Zone VAV baseline.

Supply Air Temperature Reset by Stage

Applicability	Single Zone VAV Systems with Supply Air Temperature Control Method set to *Staged Control*
Definition	This provides the cooling supply air temperature setpoint deviation from the cooling design supply air temperature, specified in the building descriptor *Cooling Supply Air Temperature*. The temperature reset is expressed as an array, with each entry a deviation from the design supply air temperature. For example, an entry of “5” for a stage would indicate a 5°F reset (for example, 60°F from 55°F).
Units	Array of temperature differences, in degrees F
Input Restrictions	As Designed
Standard Design	N/A

Number of Heating Stages

Applicability	Single Zone VAV Systems and DX systems with multiple stages
Definition	The number of heating stages provided by the system. Multiple stages could be provided via a heat pump or via a multiple-stage gas furnace.
Units	Integer
Input Restrictions	As Designed
Standard Design	1

Heating Capacity by Stage

Applicability	Single Zone VAV Systems and DX systems with multiple stages
Definition	This provides the total heating capacity of each heating stage, at AHRI rated conditions. The capacity is expressed as an array, with each entry a fraction of the total rated cooling capacity for the unit. For example, if the stage heating capacity is 48,000 Btu/h and the heating capacity is 96,000 Btu/h, the capacity is expressed as “0.50” for that stage.
Units	Array of fractions
Input Restrictions	As Designed
Standard Design	N/A

Heating Supply Air Temperature by Stage

Applicability	Single Zone VAV Systems and DX systems with multiple stages
Definition	This provides the heating supply air temperature setpoint deviation from the design

heating supply air temperature, specified in the building descriptor *Heating Supply Air Temperature*.

The temperature reset is expressed as an array, with each entry a deviation from the design supply air temperature. For example, an entry of “-10” for a stage would indicate a 10°F reset (for example, 95°F from 105°F).

Units	Array of temperature differences, in degrees F
Input Restrictions	As Designed
Standard Design	N/A

Supply Fan Low Speed Ratio

Applicability	Single Zone VAV Systems and DX systems with multiple stages and two-speed fans
Definition	This specifies the low fan speed setting on a Single Zone VAV system or DX system with multiple cooling stages.
Units	None (fraction)
Input Restrictions	As Designed
Standard Design	The default shall be the greater of 0.50 or the minimum outside air fraction for the Single Zone VAV baseline.

Supply Fan Low Power Ratio

Applicability	Single Zone VAV Systems and DX systems with multiple stages and two-speed fans
Definition	This specifies the fraction of full load fan power corresponding to low fan speed operation on a Single Zone VAV system or DX system with multiple cooling stages.
Units	None (fraction)
Input Restrictions	As Designed
Standard Design	The default shall be 0.30, or the minimum power ratio calculated by applying the minimum outside air fraction to the “Any Fan with VSD” curve, for the Single Zone VAV baseline.

Minimum Unloading Ratio

Applicability	Packaged DX systems
Definition	The fraction of total cooling capacity below which compressor(s) must cycle on and off to meet the cooling load. Below the minimum unloading ratio, part-load efficiency is reduced. Also, below the minimum unloading ratio, the economizer will not operate in a fully integrated mode with compressor cooling.
Units	Ratio
Input Restrictions	As designed. The user must enter this descriptor for each DX cooling system. If hot-gas bypass is not employed, a value of 0 may be entered. 0.25 for units with a peak total cooling capacity greater than or equal to 240 kBtu/h; 0.35 for units with a peak cooling capacity greater than or equal to 65 kBtu/h and less than 240 kBtu/h

Minimum HGB Ratio

Applicability	Packaged systems which use hot-gas bypass during low load conditions
Definition	The lower end of the hot-gas bypass operating range. The percentage of peak cooling capacity below which hot-gas bypass will no longer operate (i.e. the compressor will cycle).
Units	Ratio
Input Restrictions	0
Standard Design	0

Condenser Type

Applicability:	All direct expansion systems including heat pumps
Definition	The type of condenser for a direct expansion (DX) cooling system. The choices are: • Air-Cooled • Water-Cooled • Air-Cooled with Evaporative Pre-cooler
Units	List (see above)
Input Restrictions	As designed
Standard Design	Based on the prescribed system type. Refer to the HVAC System Map section 5.7.1. Air-cooled for Systems 1 (PTAC), 3, (PSZ), 5 (PVAV) and 11 (CRAC). Not applicable for other standard design systems.

Condenser Flow Type

Applicability:	All direct expansion systems including heat pumps
Definition	Describes water flow control for a water-cooled condenser. The choices are: • Fixed Flow • Two-position • Variable Flow
Units	List (see above)
Input Restrictions	Default to fixed flow. If the variable-flow is selected, the software must indicate that supporting documentation is required on the output forms.
Standard Design	Two-position

Supplementary DX Cooling Unit

Applicability	Required when user-defined natural ventilation or evaporative cooling systems have excessive unmet load hours
Definition	The specification of a supplementary DX cooling system that must be used when the user-defined cooling system results in unmet load hours exceeding 150 for any zone
Units	List
Input Restrictions	The user shall input the following system characteristics, with one unit for each zone: Total Cooling Capacity (Btu/h)

Total Heating Capacity (Btu/h)

The compliance software shall define the following prescribed system characteristics:

Efficiency: Minimum efficiency from Table 110.2-A, based on cooling capacity

System Airflow: 350 cfm/ton cooling

Economizer: None

Design Supply Air Temperature: 55F

Supply Air Temperature Control: Fixed

Design Heating Supply Air Temperature: 105F

Standard Design Not Applicable

5.7.5.3 Evaporative Cooler

This is equipment that pre-cools the outside air that is brought into the building. It may be used with any type of cooling system that brings in outside air. This equipment is not applicable for the baseline building.

Evaporative Cooling Type

Applicability Systems with evaporative cooling

Definition The type of evaporative pre-cooler, including:

- None
- Non-Integrated Direct
- Non-Integrated Indirect
- Non-Integrated Direct/Indirect
- Integrated Direct
- Integrated Indirect
- Integrated Direct/Indirect

An integrated cooler can operate together with compressor or CHW cooling. A non-integrated cooler will shut down the evaporative cooling whenever it is unable to provide 100% of the cooling required.

Direct evaporative cooling can only be applied to the outside air. Indirect evaporative cooling can be applied to outside air or return air.

Units None

Input Restrictions As designed

Standard Design Not applicable

Evaporative Cooling System Capacity

Applicability Systems with evaporative cooling

Definition The total sensible cooling capacity of the evaporative cooling system at design outdoor dry-bulb conditions. This value may be derived from other inputs of Supply Fan Design Air Rated Capacity (5.7.3), Direct Stage Effectiveness, Indirect Stage Effectiveness and design outdoor conditions.

Units	None
Input Restrictions	Not applicable. Derived input. If there are excessive unmet load hours in any zone served by the evaporative cooling system, a Supplementary DX Cooling Unit must be defined by the user. See Section 5.7.5.2.
Standard Design	Not applicable

Direct Stage Effectiveness

Applicability Systems with evaporative cooling

Definition The effectiveness of the direct stage of an evaporative cooling system. Effectiveness is defined as follows:

(22)

$$DirectEFF = \frac{Tdb - Tdirect}{Tdb - Twb}$$

Where:

DirectEFF	The direct stage effectiveness
T_{db}	The entering air dry-bulb temperature
T_{wb}	The entering air wet-bulb temperature
T_{direct}	The direct stage leaving dry-bulb temperature

Units	Numeric (0 <= eff <=1)
Input Restrictions	As designed
Standard Design	Not applicable

Indirect Stage Effectiveness

Applicability Systems with evaporative cooling

Definition The effectiveness of the indirect stage of an evaporative cooling system. Effectiveness is defined as follows:

(23)

$$IndEFF = \frac{Tdb - Tind}{Tdb - Twb}$$

Where:

IndEFF	The indirect stage effectiveness
Tdb	The entering air dry-bulb temperature of the supply air
Twb	The entering air wet-bulb temperature of the “scavenger air”
Tind	The supply air leaving dry-bulb temperature

Units	Numeric (0 <= eff <=1)
Input Restrictions	As designed
Standard Design	Not applicable

Evaporative Cooling Performance Curves

Applicability Systems with evaporative cooling

Definition A curve that varies the evaporative cooling effectiveness as a function of primary air stream airflow. The default curves are given as follows:

(24)

$$PLR = \frac{CFM_{operating}}{CFM_{design}}$$

$$EFF\_FFLOW = a + b \times PLR + c \times PLR^2$$

Where:

PLR Part load ratio of airflow based on design airflow

EFF-FFLOW A multiplier on the evaporative cooler effectiveness to account for variations in part load

$CFM_{operating}$ Operating primary air stream airflow (cfm)

CFM_{design} Design primary air stream airflow (cfm)

Table 43 – Part Load Curve Coefficients – Evaporative Cooler Effectiveness

Coefficient	Direct	Indirect
a	1.1833000	1.0970000
b	-0.2575300	-0.1650600
c	0.0742450	0.0680690

Units Data structure

Input Restrictions User may input curves or use default curves. If defaults are overridden, the software must indicate that supporting documentation is required on the output forms.

Standard Design Not used.

Auxiliary Evaporative Cooling Power

Applicability Systems with evaporative cooling

Definition The auxiliary energy of the indirect evaporative cooler fan, and the pumps for both direct and indirect stages

Units Watts

Input Restrictions As designed

Standard Design Not applicable

Evaporative Cooling Scavenger Air Source

Applicability Systems with evaporative cooling

Definition The source of scavenger air for an indirect section of an evaporative cooler. Options include:

- Return Air
- Outside Air

Units	List (see above)
Input Restrictions	As designed
Standard Design	Not applicable

5.7.5.4 Western Cooling Challenge (WCC) Equipment

A special credit is available in the 2013 ACM for equipment (including evaporative equipment) that meets efficiency and water use requirements of the Western Cooling Challenge, a program of the Western Cooling Efficiency Center. This compliance option triggers an Exceptional Condition and documentation requirements – see Chapter 3 of the ACM Reference Manual.

This equipment is modeled as high-efficiency DX equipment, with a constant volume fan, integrated economizer and fixed performance curve. Unlike the input model for a packaged DX equipment, the WCC equipment has many building descriptor inputs fixed (prescribed); therefore, rather than listing the WCC input restrictions as an option within each building descriptor, all requirements for WCC equipment are contained in this section.

Heating equipment must be specified separately, as the WCC test procedure does not include heating conditions. The heating system may be any system other than a heat pump.

Building Descriptor	Section	Proposed Input
System Type	5.7.1	PSZ-AC and PSZVAV-AC only
Cooling Supply Air Temperature	5.7.2.2	20F below return air temperature
Cooling Supply Air Temperature Control	5.7.2.2	Fixed (single zone system)
Heating Supply Air temperature	5.7.2.3	105F
Heating Supply Air Temperature Control	5.7.2.3	Fixed (constant)
Supply Fan Design Air Rated Capacity	5.7.3	400 cfm/ton
Fan Control Method	5.7.3	Constant Volume
Supply Fan Power Index	5.7.3.2	0.365 W/cfm
Maximum Outside Air Ratio	5.7.4.1	1
Design Outside Air Flow	5.7.4.1	*(as designed)*
Economizer Control Type	5.7.4.2	Differential dry-bulb
Economizer Integration Level	5.7.4.2	Integrated
Economizer High Temperature Lockout	5.7.4.2	n/a
Economizer low temperature lockout	5.7.4.2	n/a
Cooling Source	5.7.5	DX
Total Cooling Capacity	5.7.5	As designed *(NOTE: if there are unmet load hours, the user will have to enter a larger capacity system, or add a supplemental DX unit with standard efficiency (EER~11) to meet cooling load.)*

Sensible Cooling Capacity	5.7.5	As Designed
Cooling Capacity Adjustment Curves	5.7.5	Use Air-cooled DX defaults
Coil Bypass Factor (if used)	5.7.5	0.190
Direct Expansion Cooling Efficiency	5.7.5.2	As designed *(user enters EER from WCC test, and software makes adjustment for EER, removing fan power from efficiency as needed)*
Seasonal Energy Efficiency Ratio	5.7.5.2	n/a
Direct Expansion Cooling Efficiency Temperature Adjustment Curve	5.7.5.2	Use default curve
Direct Expansion Part-Load Efficiency Adjustment Curve	5.7.5.2	Use default curve
Refrigerant Charge Factor	5.7.5.2	1
Airflow Adjustment Factor	5.7.5.2	1
Duct Leakage Rate,	5.7.5.2	As designed *(for qualifying spaces)*
Minimum Unloading Ratio	5.7.5.2	0.25 (units > 240 kBtu/h) 0.35 (units >= 65 kBtu/h and < 120 kBtu/h)
Cooling Setpoint Schedule	5.4	Use default schedule for space type (this will be 75F when occupied, in most cases)
Heating		
Heating Source	5.7.6.1	As designed (but heat pump not allowed)
Preheat Coil	5.7.6.2	No preheat coil
Heating Coil Capacity	5.7.6.3	As designed
Furnace Capacity	5.7.6.4	As designed
Furnace Fuel Heating Efficiency	5.7.6.3	As designed
Furnace Fuel Heating Part Load Efficiency Curve	5.7.6.4	Fixed default curve
Furnace Fuel Heating Pilot	5.7.6.4	0
Furnace Fuel Heating Fan/Auxiliary	5.7.6.4	N/A
Heat recovery	5.7.6.6	*NOT ALLOWED for this credit*
Humidity Controls and Devices	5.7.7	None

5.7.5.5 Evaporative Condenser

Evaporative Condenser Power

Applicability	Direct expansion systems with an evaporatively cooled condenser
Definition	The power of the evaporative precooling unit. This includes any pump(s) and/or fans that are part of the precooling unit.
Units	Watts
Input Restrictions	As designed
Standard Design	Not applicable

Evaporative Condenser Effectiveness

Applicability Direct expansion systems with an evaporatively cooled condenser

Definition The effectiveness of the evaporative precooling unit for a condenser. Effectiveness is defined as follows:

$$DirectEFF = \frac{Tdb - Tdirect}{Tdb - Twb} \qquad (25)$$

Where:

DirectEFF	The direct stage effectiveness
Tdb	The outside air dry-bulb temperature
Twb	The outside air wet-bulb temperature
Tdirect	The direct stage leaving dry-bulb temperature (at the condenser inlet)

Units	Ratio
Input Restrictions	As designed
Standard Design	Not applicable

Evaporative Condenser Operation Range

Applicability Direct expansion systems with an evaporatively cooled condenser.

Definition The temperature range within which the evaporative condenser operates. Two values are provided:

$T_{maximum}$	The threshold outside air dry-bulb temperature below which evaporative condenser operates.
$T_{minimum}$	The threshold outside air dry-bulb temperature above which evaporative condenser operates.

Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	Not applicable

5.7.5.6 Four-Pipe Fan Coil Systems

This section contains building descriptors required to model four-pipe fan coil systems. Note that this system requires an outside air ventilation source to serve the zones and that an airside economizer is not available.

The fan coil fans shall be modeled with the power-per-unit-flow method. The standard design fan power shall be 0.35 W/cfm when the four-pipe fan coil is the standard design system. See the supply fan ACM section 5.7.3.2 for details.

Supply air flow rates are set at the zone level. Chilled water flow rates are set according to the rules in 5.8.5, Pumps.

Note that additional HVAC components (chiller, boiler, pumps) are needed to fully define this system. If a water-side economizer is specified with this system, refer to section 5.8.4 for a list of applicable building descriptors.

Capacity Control Method	
Applicability	Four-pipe fan coil systems
Definition	The control method for the fan coil unit at the zone. The following choices are available: ConstantFanVariableFlow CyclingFan VariableFanConstantFlow VariableFanVariableFlow
Units	List (with choices above)
Input Restrictions	Not a User Input – Derived from building descriptors for fan control and chiller loop flow control
Standard Design	Cycling Fan

5.7.5.7 Radiant Cooling

This section describes a floor-based radiant cooling system and the inputs required for Title 24 compliance evaluation.

Hydronic Tubing Length	
Applicability	Floor-based radiant cooling systems
Definition	The length of the hydronic tubing in the slab
Units	ft
Input Restrictions	As designed
Standard Design	Not applicable

Hydronic Tubing Inside Diameter	
Applicability	Floor-based radiant cooling systems
Definition	The inside diameter of the hydronic tubing in the slab

Units	ft
Input Restrictions	As designed, between a minimum of ½" and a maximum of ¾"
Standard Design	Not applicable

Temperature Control Type

Applicability	Floor-based radiant cooling systems
Definition	The temperature used for control (operative temperature, mean air temperature, mean radiant temperature, ODB, OWB
Units	None
Input Restrictions	Fixed at Mean Air Temperature for compliance calculations
Standard Design	Not applicable

Cooling Control Temperature

Applicability	Variable Flow Systems
Definition	The temperature used for control (operative temperature, mean air temperature, mean radiant temperature, ODB, OWB
Units	None
Input Restrictions	Fixed at Mean Air Temperature for compliance calculations
Standard Design	Not applicable

Condensation Control Type

Applicability	Floor-based radiant cooling systems
Definition	The temperature used for control (operative temperature, mean air temperature, mean radiant temperature, ODB, OWB
Units	None
Input Restrictions	Fixed at Mean Air Temperature for compliance calculations
Standard Design	Not applicable

Condensation Control Dewpoint Offset

Applicability	Floor-based radiant cooling systems
Definition	The temperature difference above dewpoint that is the minimum cold water supply temperature
Units	None
Input Restrictions	Fixed at 2°F above dewpoint
Standard Design	Not applicable

Rated Pump Power Consumption

Applicability	Floor-based radiant cooling systems
Definition	The rated pump power at design conditions
Units	Watts
Input Restrictions	

	As Designed
Standard Design	Not applicable

Motor Efficiency

Applicability	Floor-based radiant cooling systems
Definition	The pump motor efficiency
Units	Decimal fraction
Input Restrictions	As Designed
Standard Design	Default motor efficiency from Table N2-20 (*Table numbering may change*) based on motor nameplate hp

Fraction of Motor Heat to Fluid

Applicability	Floor-based radiant cooling systems
Definition	Fraction of the heat from the motor inefficiencies that enters the fluid stream
Units	none
Input Restrictions	As designed. Default is 0.
Standard Design	Not applicable

Cooling High Water Temperature

Applicability	Floor-based radiant cooling systems
Definition	The high temperature used for control. If the water temperature is above the high temperature, the control temperature is set to the low control temperature.
Units	Deg F
Input Restrictions	As Designed
Standard Design	Not applicable

Cooling Low Water Temperature

Applicability	Floor-based radiant cooling systems
Definition	The temperature used for control of the water temperature. If the water temperature of the radiant cooling is below this temperature, cooling is disabled.
Units	Deg F
Input Restrictions	Fixed at 55°F
Standard Design	Not applicable

Condensation Control Type

Applicability	Floor-based radiant cooling systems
Definition	The simulation program may have a means of detecting when condensation is likely to occur on floor surfaces in the space. When this occurs, the simulation can shut off the system to prevent condensation from occurring.
Units	List: None, Simple, Variable

Input Restrictions	As designed
Standard Design	Not applicable

5.7.5.8 Chilled Beams

Reserved. Building descriptors will be added to define how chilled beams can be modeled for the proposed design. Chilled beams are not applicable to the standard design system.

5.7.5.9 Ground-Source Heat Pumps

Reserved. Building descriptors will be added to define how ground-source heat pumps (GSHP) can be modeled for the proposed design. GSHP are not applicable to the standard design system.

5.7.5.10 Variable Refrigerant Flow

Reserved. Building descriptors will be added to define how VRF systems can be modeled for the proposed design. VRF are not applicable to the standard design system.

5.7.5.11 Underfloor Air Distribution

Reserved. Building descriptors will be added to define how UFAD systems can be modeled for the proposed design. UFAD systems are not applicable to the standard design system.

5.7.6 Heating Systems

5.7.6.1 General

Heating Source

Applicability	All systems that provide heating
Definition	The source of heating for the heating and preheat coils. The choices are: • Hot water • Steam • Electric resistance • Electric heat pump • Gas furnace • Gas heat pump (optional feature) • Oil furnace • Heat recovery
Units	List (see above)
Input Restrictions	As designed
Standard Design	Based on the prescribed system type. Refer to the HVAC System Map in Section 5.1.2.

Table 44 – Heating Source for Baseline Building

Baseline Building System	Heating Source
System 1 – PTAC	Hot water
System 2 – FPFC	Hot water
System 3 – PSZ-AC	Gas or Oil Furnace
System 5 – Packaged VAV with Reheat	Hot water
System 6 – VAV with Reheat	Hot water
System 7 – Single Zone VAV	Gas Furnace
System 9 – Heating and Ventilation	Gas Furnace
System 10 – CRAH Unit, Data Center	None
System 11 – CRAC Unit, Data Center	None

5.7.6.2 Preheat Coil

Preheat Coil Capacity

Applicability	Systems with a preheat coil located in the outside air stream
Definition	The heating capacity of a preheating coil at design conditions.
Units	Btu/h
Input Restrictions	As designed
Standard Design	not applicable

Preheat Coil Efficiency

Applicability	Systems with a preheat coil with gas heating
Definition	The heating efficiency of a preheating coil at design conditions.
Units	Percentage
Input Restrictions	As designed. Default is 80%.
Standard Design	Not applicable

5.7.6.3 Hydronic/Steam Heating Coils

Systems with boilers have heating coils, including baseline building systems with hot water heating.

Heating Coil Capacity

Applicability	All systems with a heating coil
Definition	The heating capacity of a heating coil at AHRI conditions
Units	Btu/h
Input Restrictions	As designed. The user may need to manually adjust the capacity if the number of unmet load hours exceeds 150.
Standard Design	Autosize with a heating oversizing factor of 25%. If the number of unmet load hours for the baseline exceeds, reduce the heating coil capacity as indicated in Section 2.6.2.

5.7.6.4 Furnace

Furnace Capacity

Applicability	Systems with a furnace
Definition	The full load heating capacity of the unit
Units	Btu/h
Input Restrictions	As designed. The user may need to manually adjust the capacity if the number of unmet load hours exceeds 150.
Standard Design	Autosize with an oversizing factor of 25% (let the software determine heating capacity based on the building loads). If the number of unmet load hours for the baseline exceeds 150, reduce the furnace capacity as indicated in Figure 2 and 2.6.2

Furnace Fuel Heating Efficiency

Applicability Systems with a furnace

Definition The full load thermal efficiency of either a gas or oil furnace at design conditions. The software must accommodate input in either *Thermal Efficiency* (E_t) or *Annual Fuel Utilization Efficiency* (AFUE). Where AFUE is provided, E_t shall be calculated as follows:

(26)

$$E_t = 0.005163 \times AFUE + 0.4033$$

where

AFUE	The annual fuel utilization efficiency (%)
Et	The thermal efficiency (fraction)

Units Fraction

Input Restrictions As designed

Standard Design Look up the requirement from the equipment efficiency tables in Table 6.8.1E of the Standard. The baseline efficiency requirement is located in Table E-3 or Table E-4 of the 2010 Appliance Efficiency Standards. Use the heating input of the standard design system to determine the size category.

Furnace Fuel Heating Part Load Efficiency Curve

Applicability Systems with furnaces

Definition An adjustment factor that represents the percentage of full load fuel consumption as a function of the percentage full load capacity. This curve shall take the form of a quadratic equation as follows:

(27)

$$Fuel_{partload} = Fuel_{rated} \times FHeatPLC$$

(28)

$$FHeatPLC = \left(a + b \times \frac{Q_{partload}}{Q_{rated}} + c \times \left(\frac{Q_{partload}}{Q_{rated}} \right)^2 \right)$$

Where:

FHeatPLC	The Fuel Heating Part Load Efficiency Curve
$Fuel_{partload}$	The fuel consumption at part load conditions (Btu/h)
$Fuel_{rated}$	The fuel consumption at full load (Btu/h)
$Q_{partload}$	The capacity at part load conditions (Btu/h)
Q_{rated}	The capacity at rated conditions (Btu/h)

Table 45 – Furnace Efficiency Curve Coefficients

Coefficient	Furnace
a	0.0186100
b	1.0942090
c	-0.1128190

Units Data structure

Input Restrictions Fixed

Standard Design Fixed

Furnace Fuel Heating Pilot

Applicability Systems that use a furnace for heating

Definition The fuel input for a pilot light on a furnace

Units Btu/h

Input Restrictions As designed

Standard Design Zero (pilotless ignition)

Furnace Fuel Heating Fan/Auxiliary

Applicability Systems that use a furnace for heating

Definition The fan energy in forced draft furnaces and the auxiliary (pumps and outdoor fan) energy in fuel-fired heat pumps

Units Kilowatts (kW)

Input Restrictions As designed

Standard Design Not applicable

5.7.6.5 Electric Heat Pump

Electric Heat Pump Heating Capacity

Applicability All heat pumps

Definition The full load heating capacity of the unit, excluding supplemental heating capacity at AHRI rated conditions

Units Btu/h

Input Restrictions As designed

Standard Design Autosize and use an oversizing factor of 25% (let the software determine heating capacity based on the building loads).

Electric Heat Pump Supplemental Heating Source

Applicability All heat pumps

Definition The auxiliary heating source for a heat pump heating system. The common control sequence is to lock out the heat pump compressor when the supplemental heat is activated. Other building descriptors may be needed if this is not the case. Choices for supplemental heat include:

- Electric resistance
- Gas furnace
- Oil furnace
- Hot water
- Other

Units List (see above)

Input Restrictions As designed

Standard Design Electric resistance

Electric Heat Pump Heating Efficiency

Applicability All heat pumps

Definition The heating efficiency of a heat pump at AHRI rated conditions as a dimensionless ratio of output over input. The software must accommodate user input in terms of either the *Coefficient of Performance* (COP) or the *Heating Season Performance Factor* (HSPF). Where HSPF is provided, COP shall be calculated as follows:

(29)

COP = 0.2778 x HSPF + 0.9667

For all unitary and applied equipment where the fan energy is part of the equipment efficiency rating, the COP shall be adjusted as follows to remove the fan energy:

(30)

$$COP_{adj} = \frac{\dfrac{HCAP_{rated} - Q_{fan,rated}}{3.413}}{\dfrac{HCAP_{rated}}{COP \times 3.413} - \dfrac{Q_{fan,rated}}{3.413}}$$

Where:

COP_{adj}	The adjusted coefficient of performance for simulation purposes
COP	The AHRI rated coefficient of performance
$HCAP_{rated}$	The AHRI rated heating capacity of a packaged unit (kBtu/h)

	Qfan,rated	ARI rated fan power, equal to the gross rated cooling capacity times 0.040.

Units Unitless

Input Restrictions As designed

Standard Design Not applicable

Electric Heat Pump Heating Capacity Adjustment Curve(s)

Applicability All heat pumps

Definition A curve or group of curves that represent the available heat-pump heating capacity as a function of evaporator and condenser conditions. The default curves are given as follows:

(31)

$$Q_{available} = CAP\_FT \times Q_{rated}$$

(32)

For air-cooled heat pumps:

$$CAP\_FT = a + b \times t_{odb} + c \times t_{odb}^{\ 2} + d \times t_{odb}^{\ 3}$$

(33)

For water-cooled heat pumps:

$$CAP\_FT = a + b \times t_{db} + d \times t_{wt}$$

Where:

$Q_{available}$	Available heating capacity at present evaporator and condenser conditions (kBtu/h)
t_{db}	The entering coil dry-bulb temperature (°F)
t_{wt}	The water supply temperature (°F)
t_{odb}	The outside-air dry-bulb temperature (°F)
Q_{rated}	Rated capacity at AHRI conditions (in kBtu/h)

Table 46 – Heat Pump Capacity Adjustment Curves (CAP-FT)

Coefficient	Water-Source	Air-Source
a	0.4886534	0.2536714
b	-0.0067774	0.0104351
c	N/A	0.0001861
d	0.0140823	-0.0000015

Units Data structure

Input Restrictions Fixed – Use curves in Table 45 for water-source or air-source heat pumps as appropriate.

Standard Design Not applicable.

Electric Heat Pump Heating Efficiency Adjustment Curve(s)

Applicability All heat pumps

Definition A curve or group of curves that varies the heat-pump heating efficiency as a function of evaporator conditions, condenser conditions and part-load ratio. The default curves are given as follows:

$$PLR = \frac{Q_{operating}}{Q_{available}(t_{db}, t_{odb/wt})} \quad (34)$$

$$EIR\_FPLR = a + b \times PLR + c \times PLR^2 + d \times PLR^3 \quad (35)$$

Air Source Heat Pumps:

$$EIR\_FT = a + b \times t_{odb} + c \times t_{odb}{}^2 + d \times t_{odb}{}^3 \quad (36)$$

Water Source Heat Pumps:

$$EIR\_FT = a + b \times t_{wt} + d \times t_{db} \quad (37)$$

$$P_{operating} = P_{rated} \times EIR\_FPLR \times EIR\_FT \times CAP\_FT \quad (38)$$

Where:

PLR	Part load ratio based on available capacity (not rated capacity)
EIR-FPLR	A multiplier on the EIR of the heat pump as a function of part load ratio
EIR-FT	A multiplier on the EIR of the heat pump as a function of the wet-bulb temperature entering the coil and the outdoor dry-bulb temperature
$Q_{operating}$	Present load on heat pump (Btu/h)
$Q_{available}$	Heat pump available capacity at present evaporator and condenser conditions (Btu/h) .
t_{db}	The entering coil dry-bulb temperature (°F)
t_{wt}	The water supply temperature (°F)
t_{odb}	The outside air dry-bulb temperature (°F)
P_{rated}	Rated power draw at AHRI conditions (kW)
$P_{operating}$	Power draw at specified operating conditions (kW)

Table 47 – Heat Pump Heating Efficiency Adjustment Curves

Coefficient	Air-and Water-Source EIR-FPLR	Water-Source EIR-FT	Air-Source EIR-FT
a	0.0856522	1.3876102	2.4600298
b	0.9388137	0.0060479	-0.0622539
c	-0.1834361	N/A	0.0008800
d	0.1589702	-0.0115852	-0.0000046

Units None

Input Restrictions Fixed – use appropriate curve from Table 46

Standard Design Not applicable

Electric Heat Pump Supplemental Heating Capacity

Applicability All heat pumps

Definition The design heating capacity of a heat pump supplemental heating coil at AHRI conditions

Units Btu/h

Input Restrictions As designed

Standard Design Not applicable

Electric Supplemental Heating Control Temp

Applicability All heat pumps

Definition The outside dry-bulb temperature below which the heat pump supplemental heating is allowed to operate

Units Degrees Fahrenheit (°F)

Input Restrictions As designed. Default to 40°F

Standard Design Not applicable

Heat Pump Compressor Minimum Operating Temp

Applicability All heat pumps

Definition The outside dry-bulb temperature below which the heat pump compressor is disabled

Units Degrees Fahrenheit (°F)

Input Restrictions As designed.

Standard Design Not applicable

Coil Defrost

Applicability Air-cooled electric heat pump

Definition The defrost control mechanism for an air-cooled heat pump. The choices are:

- Hot-gas defrost, on-demand
- Hot-gas defrost, timed 3.5 minute cycle

- Electric resistance defrost, on-demand
- Electric resistance defrost, timed 3.5 minute cycle

Defrost shall be enabled whenever the outside air dry-bulb temperature drops below 40°F.

Units	List (see above)
Input Restrictions	Default to use hot-gas defrost, timed 3.5 minute cycle. User may select any of the above.
Standard Design	Not applicable

Coil Defrost kW

Applicability	Heat pumps with electric resistance defrost
Definition	The capacity of the electric resistance defrost heater
Units	Kilowatts (kW)
Input Restrictions	As designed. This descriptor defaults to 0 if nothing is entered.
Standard Design	Not applicable.

Crank Case Heater kW

Applicability	All heat pumps
Definition	The capacity of the electric resistance heater in the crank case of a direct expansion (DX) compressor. The crank case heater operates only when the compressor is off.
Units	Kilowatts (kW)
Input Restrictions	As designed. This descriptor defaults to 0.1 if nothing is entered.
Standard Design	Not applicable

Crank Case Heater Shutoff Temperature

Applicability	All heat pumps
Definition	The outdoor air dry-bulb temperature above which the crank case heater is not permitted to operate.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed. This descriptor defaults to 50°F.
Standard Design	Not applicable

5.7.6.6 Heat Recovery

Exhaust Air Sensible Heat Recovery Effectiveness

Applicability	Any system with outside air heat recovery
Definition	The effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams. Effectiveness is defined as follows:

(39)

$$HREFF = \frac{(EEAdb - ELAdb)}{(EEAdb - OSAdb)}$$

Where:

HREFF	The air-to-air heat exchanger effectiveness
EEAdb	The exhaust air dry-bulb temperature entering the heat exchanger
ELAdb	The exhaust air dry-bulb temperature leaving the heat exchanger
OSAdb	The outside air dry-bulb temperature

Units Ratio between 0 and 1

Input Restrictions As designed

Standard Design Not applicable

Exhaust Air Latent Heat Recovery Effectiveness

Applicability Any system with outside air enthalpy heat recovery

Definition The latent heat recovery effectiveness of an air-to-air heat exchanger between the building exhaust and entering outside air streams. Effectiveness is defined as follows:

(40)

$$HREFF = \frac{(EEAw - ELAw)}{(EEAw - OSAw)}$$

Where:

HREFF	The air-to-air heat exchanger effectiveness
EEAw	The exhaust air humidity ratio (fraction of mass of moisture in air to mass of dry air) entering the heat exchanger
ELAdb	The exhaust air humidity ratio leaving the heat exchanger
OSAdb	The outside air humidity ratio

Note that for sensible heat exchangers this term is not applicable.

Units Ratio between 0 and 1

Input Restrictions As designed

Standard Design Not applicable

Condenser Heat Recovery Effectiveness

Applicability Systems that use recover heat from a condenser

Definition The percentage of heat rejection at design conditions from a DX or heat pump unit in cooling mode that is available for space or water heating.

Units Percent (%)

Input Restrictions As designed. The software must indicate that supporting documentation is required on the output forms if heat recovery is specified.

Standard Design Not applicable

Heading: Heat Recovery Use

Applicability	Systems that use heat recovery
Definition	The end use of the heat recovered from a DX or heat pump unit. The choices are: • Reheat coils • Water heating
Units	List (see above)
Input Restrictions	As designed. The software must indicate that supporting documentation is required on the output forms if heat recovery is specified.
Standard Design	Not applicable for most conditions. The end use will be water heating if required for 24-hour facility operation. Not applicable

5.7.7 Humidity Controls and Devices

5.7.7.1 General

Humidifier Type

Applicability	Optional humidifier
Definition	The type of humidifier employed. Choices include: • Hot-Water • Steam • Electric • Evaporative Humidification
Units	List (see above)
Input Restrictions	As designed
Standard Design	Not applicable

Humidistat Maximum Setting

Applicability	Systems with humidity control
Definition	The control setpoint for dehumidification
Units	Percent (%)
Input Restrictions	As designed
Standard Design	Not applicable

Humidistat Minimum Setting

Applicability	Systems with humidity control
Definition	The control setpoint for humidification
Units	Percent (%)
Input Restrictions	As designed
Standard Design	Not applicable

5.7.7.2 Desiccant

Desiccant Type

Applicability	Systems with desiccant dehumidification
Definition	Describes the configuration of desiccant cooling equipment The following configurations for desiccant systems are allowed: • LIQ-VENT-AIR1 – a liquid desiccant dehumidifying unit • LIQ-VENT-AIR2 – a liquid desiccant dehumidifying unit combined with a gas-fired absorption chiller • SOL-VENT-AIR1 – a solid desiccant dehumidifying unit • NO-DESICCANT – the default, which indicates that no desiccant system is present
Units	List (see above)
Input Restrictions	As designed
Standard Design	Not applicable

Desiccant Control Mode

Applicability	Systems with desiccant dehumidification
Definition	The method of controlling the operation of the desiccant unit. For liquid-based systems this can be either: • Dry-bulb – the desiccant unit is turned on whenever the outside air dry-bulb exceeds a set limit. • Evaporative cooling– cycles the desiccant unit on when an evaporative cooler is on to maintain a dewpoint setpoint. • Dewpoint – cycles the desiccant unit on and off to maintain the dewpoint temperature of the supply air. For solid-based systems the following configurations are possible: • Dehumidification only – the desiccant unit cycles on and off to maintain indoor humidity levels • Sensible heat exchanger plus regeneration – the desiccant unit includes a sensible heat exchanger to precool the hot, dry air leaving the desiccant unit. The air leaving the exhaust side of the heat exchanger is directed to the desiccant unit • Sensible heat exchanger – the desiccant unit includes a heat exchanger, but the air leaving the exhaust side of the heat exchanger is exhausted to the outdoors
Units	List (see above)
Input Restrictions	As designed
Standard Design	Not applicable

Desiccant Air Fraction

Applicability	Systems with desiccant dehumidification
Definition	The fraction of the supply air that passes through the desiccant unit. Typically either

	the minimum outside air fraction or all of the air passes through the desiccant system.
Units	Ratio
Input Restrictions	As designed
Standard Design	Not applicable

Desiccant Heat Source

Applicability	Systems with desiccant dehumidification
Definition	The source of heat that is used to dry out the desiccant. This can be either:

- Gas – Hydronic – the regeneration heat load is met with a gas-fired heater
- Hot water – the heat load is met with hot water from the plant

Units	List (see above)
Input Restrictions	As designed
Standard Design	Not applicable

Liquid Desiccant Performance Curves

Applicability	Systems with liquid-based desiccant dehumidification
Definition	A set of performance curves that apply to liquid desiccant systems.

- $$DESC-T-FTW = a + b \times T + c \times T^2 + d \times w + e \times w^2 + f \times T \times w \quad (41)$$
- $$DESC-W-FTW = a + b \times T + c \times T^2 + d \times w + e \times w^2 + f \times T \times w \quad (42)$$
- $$DESC-Gas-FTW = a + b \times T + c \times T^2 + d \times w + e \times w^2 + f \times T \times w \quad (43)$$
- $$DESC-kW-FTW = a + b \times T + c \times T^2 + d \times w + e \times w^2 + f \times T \times w \quad (44)$$

Where:

DESC-T-FTW	dry-bulb temperature leaving desiccant unit
DESC-W-FTW	humidity ratio leaving desiccant unit
DESC-Gas-FTW	Gas usage of desiccant unit
DESC-kW-FTW	Electric usage of desiccant unit
T	entering air temperature
w	entering humidity ratio

Table 48 – Liquid Desiccant Unit Performance Curves

Coefficient	DESC-T-FTW	DESC-W-FTW	DESC-Gas-FTW	DESC-kW-FTW
a	11.5334997	11.8993998	58745.8007813	3.5179000
b	0.6586730	-0.2695580	-1134.4899902	-0.0059317
c	-0.0010280	0.0044549	-3.6676099	0.0000000
d	0.2950410	0.0830525	3874.5900879	0.0040401
e	-0.0001700	0.0006974	-1.6962700	0.0000000
f	-0.0008724	0.0015879	-13.0732002	0.0000000

Units Data structure

Input Restrictions As designed, default to values in Table 48

Standard Design Not applicable

Desiccant Dewpoint Temperature Setpoint

Applicability Systems with desiccant dehumidification

Definition The setpoint dewpoint temperature of the air leaving the desiccant system

Units Degrees Fahrenheit (°F)

Input Restrictions As designed. Defaults to 50°F.

Standard Design Not applicable

Desiccant Heat Exchanger Effectiveness

Applicability Systems with desiccant dehumidification

Definition The effectiveness of a sensible heat exchanger used with a desiccant system

Units Ratio

Input Restrictions As designed

Standard Design Not applicable

Desiccant Heat Exchanger Pressure Drop

Applicability Systems with desiccant dehumidification

Definition The pressure drop across a sensible heat exchanger used with a desiccant system

Units in. H_2O

Input Restrictions As designed. Defaults to 1.0 in. H_2O

Not applicable

5.8 HVAC Primary Systems

5.8.1 Boilers

Boiler Name

Applicability All boilers

Definition A unique descriptor for each boiler, heat pump, central heating heat-exchanger or heat recovery device.

Units None

Input Restrictions User entry. Where applicable, this should match the tags that are used on the plans for the proposed design.

Standard Design Boilers are only designated in the baseline model if the Baseline System type uses hot water for space heating.

Boiler Fuel Source

Applicability All boilers

Definition The fuel source for the central heating equipment. The choices are:

- Gas
- Oil
- Electricity

Units List (see above)

Input Restrictions As designed

This input is restricted, based on the choice of Boiler Type, according to the following rules:

	Electricity	Gas	Steam
Steam Boiler			Allowed
Hot Water Boiler		Allowed	

Standard Design Gas

Boiler Type

Applicability All boilers

Definition The boiler type. Choices include:

- Steam Boiler
- Hot Water Boiler
- Heat-Pump Water Heater

Units List (see above)

Input Restrictions As designed

Standard Design Hot water boiler

Boiler Draft Type

Applicability	All boilers
Definition	How combustion airflow is drawn through the boiler. Choices are: • Natural (sometimes called atmospheric) • Mechanical Natural draft boilers use natural convection to draw air for combustion through the boiler. Natural draft boilers are subject to outside air conditions and the temperature of the flue gases. Mechanical draft boilers enhance the air flow in one of three ways: 1) Induced draft, which uses ambient air, a steam jet, or a fan to induce a negative pressure which pulls flow through the exhaust stack; 2) Forced draft, which uses a fan and ductwork to create a positive pressure that forces air into the furnace, and 3) Balanced draft, which uses both induced draft and forced draft methods to bring air through the furnace, usually keeping the pressure slightly below atmospheric.
Units	List (see above)
Input Restrictions	As designed.
Standard Design	Mechanical (forced).

Number of Identical Boiler Units

Applicability	All boilers
Definition	The number of identical units for staging
Units	Numeric: integer
Input Restrictions	As designed. Default is 1.
Standard Design	The baseline building shall have one boiler for a when the baseline plant serves a conditioned floor area of 15,000 ft^2 or less, and have two equally size boilers for plants serving more than 15,000 ft^2.

Boiler Design Capacity

Applicability	All boilers
Definition	The heating capacity at design conditions
Units	Btu/h
Input Restrictions	As designed. If unmet load hours exceed 150, the user may need to manually adjust boiler design capacity.
Standard Design	The boiler is sized to be 25% larger than the peak loads of the baseline building. Baseline boilers shall be sized using weather files containing 99.6% heating design temperatures and 0.5% dry-bulb and 1% wet-bulb cooling design temperatures.

Boiler Efficiency Type

Applicability	All boilers
Definition	The full load efficiency of a boiler is expressed as one of the following:

- *Annual Fuel Utilization Efficiency* (AFUE) is a measure of the boiler's efficiency over a predefined heating season.
- *Thermal Efficiency* (E_t) is the ratio of the heat transferred to the water divided by the heat input of the fuel.
- *Combustion Efficiency* (E_c) is the measure of how much energy is extracted from the fuel and is the ratio of heat transferred to the combustion air divided by the heat input of the fuel.

Units List (see above)

Input Restrictions *None*

Standard Design *Annual Fuel Utilization Efficiency* (AFUE), for all gas and oil-fired boilers with less than 300,000 Btu/h capacity.

Thermal Efficiency (E_t), for all gas and oil-fired boilers with capacities between 225,000 and 2,500,000 Btu/h.

Combustion Efficiency (E_c), for all gas and oil-fired boilers with capacities above 2,500,000 Btu/h.

Boiler Efficiency

Applicability All boilers

Definition The full load efficiency of a boiler at rated conditions (see efficiency type above) expressed as a dimensionless ratio of output over input. The software must accommodate input in either *Thermal Efficiency* (E_t), *Combustion Efficiency* (E_c) or *Annual Fuel Utilization Efficiency* (AFUE). The software shall make appropriate conversions to thermal efficiency if either AFUE or combustion efficiency is entered as the rated efficiency.

Where AFUE is provided, E_t shall be calculated as follows:

$$
\begin{aligned}
&1)\ 75\% \le \text{AFUE} < 80\% \\
&E_t = 0.1 \times AFUE + 72.5\% \\
&2)\ 80\% \le \text{AFUE} \le 100\% \\
&E_t = 0.875 \times AFUE + 10.5\%
\end{aligned}
\tag{45}
$$

If combustion efficiency is entered, the compliance software shall convert the efficiency to thermal efficiency by the relation:

$$E_t = E_c - 0.015$$

All electric boilers will have an efficiency of 98%.

Units Ratio

Input Restrictions As designed

Standard Design Boilers for the baseline design are assumed to have the minimum efficiency as listed in Table E-4 of the 2009 CEC Appliance Efficiency Standards.

Boiler Part-Load Performance Curve

Applicability All boilers

Definition An adjustment factor that represents the percentage full load fuel consumption as a function of the percentage full load capacity. This curve shall take the form of a quadratic equation as follows:

(46)

$$Fuel_{partload} = Fuel_{design} \times FHeatPLC\left(Q_{partload}, Q_{rated}\right)$$

$$FHeatPLC = \left(a + b \times \frac{Q_{partload}}{Q_{rated}} + c \times \left(\frac{Q_{partload}}{Q_{rated}}\right)^2\right)$$

Where:

FHeatPLC	The Fuel Heating Part Load Efficiency Curve
$Fuel_{partload}$	The fuel consumption at part load conditions (Btu/h)
$Fuel_{design}$	The fuel consumption at design conditions (Btu/h)
$Q_{partload}$	The boiler capacity at part load conditions (Btu/h)
Q_{rated}	The boiler capacity at design conditions (Btu/h)
a	Constant
b	Constant
c	Constant

Units Ratio

Input Restrictions Prescribed to the part-load performance curve in ACM Appendix 5.7, based on the Boiler Draft Type.

Standard Design The baseline building uses the mechanical draft fan curve in Appendix 5.7.

Boiler Forced Draft Fan Power

Applicability All mechanical draft boilers

Definition The fan power of the mechanical draft fan at design conditions.

Units Nameplate Horsepower

Input Restrictions As designed.

The software shall convert the user entry of motor HP to fan power in Watts by the following equation:

Fan Power = Motor HP x 746 x 0.5

Standard Design Sized for an energy input ratio of 0.001018.(0.2984 W per kBtu/h heat input).

Boiler Minimum Unloading Ratio

Applicability All boilers

Definition The minimum unloading capacity of a boiler expressed as a percentage of the rated capacity. Below this level the boiler must cycle to meet the load.

Units Percent (%)

Input Restrictions	As designed. If the user does not use the default value the software must indicate that supporting documentation is required on the output forms. Fixed at 1% (this accounts for jacket losses and start/stop losses).
Standard Design	1%

Boiler Minimum Flow Rate

Applicability	All boilers
Definition	The minimum flow rate recommended by the boiler manufacturer for stable and reliable operation of the boiler.
Units	gpm
Input Restrictions	As designed. If the boiler(s) is piped in a primary only configuration in a variable flow system then the software shall assume there is a minimum flow bypass valve that allows the HW pump to bypass water from the boiler outlet back to the boiler inlet to maintain the minimum flow rate when boiler is enabled. Note that the boiler entering water temperature must accurately reflect the mixed temperature (colder water returning from the coil(s) and hotter bypass water) in order to accurately model boiler efficiency as a function of boiler entering water temperature.
Standard Design	0 gpm

Hot Water Supply Temperature

Applicability	All boilers
Definition	The temperature of the water produced by the boiler and supplied to the hot water loop
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	Use 180°F for baseline boiler

Hot Water Return Temperature

Applicability	All boilers
Definition	The temperature of the water returning to the boiler from the hot water loop
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	Use 140°F for baseline boiler design.

Hot Water Supply Temperature Reset

Applicability	All boilers
Definition	Variation of the hot water supply temperature with outdoor air temperature.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed (Not allowed for non-condensing boilers)
Standard Design	The hot water supply temperature should vary according to the following:

- 180°F when outside air is < 20°F
- ramp linearly between 180°F & 150°F when outdoor air is between 20°F and 50°F
- 150°F when outdoor air is > 50°F

5.8.2 Chillers

Chiller Name	
Applicability	All chillers
Definition	A unique descriptor for each chiller
Units	Text, unique
Input Restrictions	User entry. Where applicable, this should match the tags that are used on the plans.
Standard Design	Chillers are only designated when the baseline system uses chilled water

Chiller Type

Applicability All chillers

Definition The type of chiller, either a vapor-compression chiller or an absorption chiller.

Vapor compression chillers operate on the reverse-Rankine cycle, using mechanical energy to compress the refrigerant, and include:

- Reciprocating*
- Scroll*
- Screw*
- Centrifugal – uses rotating impeller blades to compress the air and impart velocity
-
- Indirect Fired Single Effect Absorption – uses a single generator and condenser
-

* *Positive displacement – includes reciprocating (piston-style), scroll and screw compressors*

Units List (see above) The software shall support all chiller types listed above

Input Restrictions As designed

Standard Design The baseline building chiller is based on the design capacity of the standard design (baseline) as follows:

Table 49 – Type and Number of Chillers

Building Peak Cooling Load	Number and Type of Chiller(s)
<= 300 tons	1 water-cooled screw chiller
>300 tons, < 600 tons	2 water-cooled screw chillers, sized equally
>= 600 tons	A minimum of two (2) water-cooled centrifugal chillers, sized to keep the unit size below 800 tons

Number of Identical Chiller Units

Applicability All chillers

Definition The number of identical units for staging.

Units None

Input Restrictions As designed. Default is 1.

Standard Design From Table 49 above.

Chiller Fuel Source

Applicability All chillers

Definition The fuel source for the chiller. The choices are:

- Electricity (for all vapor-compression chillers)
- Gas (Absorption units only, designated as direct-fired units)
- Hot Water (Absorption units only, designated as indirect-fired units)
- Steam (Absorption units only, designated as indirect-fired units)

Units List (see above)

Input Restrictions As designed.

This input is restricted, based on the choice of Chiller Type, according to the following rules:

	Electricity	Gas	Hot Water	Steam
Reciprocating	allowed			
Scroll	Allowed			
Screw	Allowed			
Centrifugal	Allowed			
Indirect Fired Single-Effect Absorption	N/A	N/A	Allowed	N/A

Standard Design Electricity

Chiller Rated Capacity

Applicability All chillers

Definition The cooling capacity of a piece of heating equipment at rated conditions.

Units

	Btu/h or tons
Input Restrictions	As designed. The user may need to manually adjust the capacity if the number of unmet load hours exceeds 150.
Standard Design	Determine loads for baseline building and oversize by 15%.

Chiller Rated Efficiency

Applicability	All chillers
Definition	The Efficiency of the chiller (Energy Efficiency Ratio (EER) for air-cooled chillers, kW/ton for water-cooled electric chillers and COP for fuel-fired and heat-driven chillers) at AHRI 550/590 rated full-load conditions.
Units	Ratio (kW/ton, COP, EER, depending on Chiller Type and Condenser Type) Water-cooled electric chiller: kW/ton Air-cooled or evaporatively cooled electric chiller: EER All non-electric chillers: COP
Input Restrictions	As designed. Must meet the minimum requirements of Table 110.2-D. Where no Path B requirements are identified, the chiller must meet minimum efficiency requirements of Path A.
Standard Design	Use the minimum efficiency requirements from Tables 110.2-D Path B. If Chiller Type is Reciprocating, Scroll or Screw, use the efficiency for *Positive Displacement* chillers from Table 110.2-D.

Integrated Part-Load Value

Applicability	All chillers
Definition	The part-load efficiency of a chiller developed from a weighted average of four rating conditions, according to AHRI Standard 550.
Units	
	Ratio (kW/ton, COP, EER, depending on Chiller Type and Condenser Type) Water-cooled electric chiller: kW/ton Air-cooled or evaporatively cooled electric chiller: EER All non-electric chillers: COP
Input Restrictions	As designed. Must meet the minimum requirements of Table 110.2-D.
Standard Design	Not used. When the standard design system has a chiller, the standard design will always use Path B performance curves.

Chiller Minimum Unloading Ratio

Applicability	All chillers
Definition	The minimum unloading capacity of a chiller expressed as a fraction of the rated capacity. Below this level the chiller must either cycle to meet the load or false-load the compressor (such as with hot gas bypass).

Table 50 – Default Minimum Unloading Ratios

Chiller Type	Default Unloading Ratio
Reciprocating	25%
Screw	15%
Centrifugal	10%
Scroll	25%
Single Effect Absorption	10%
Double Effect Absorption	10%

Units Percent (%)

Input Restrictions As designed, but constrained to a minimum value of 10%. If the user does not employ the default values, supporting documentation is required.

Standard Design Use defaults listed above.

Chiller Minimum Part Load Ratio

Applicability All chillers

Definition The minimum unloading capacity of a chiller expressed as a fraction of the rated capacity. Below this level the chiller must cycle to meet the load. If the chiller minimum part-load ratio (PLR) is less than the chiller minimum unloading ratio, then the compliance software shall assume hot gas bypass operation between the minimum PLR and the minimum unloading ratio.

Units Percent (%)

Input Restrictions As designed, but constrained to a minimum value of 10%. If the user does not employ the default values, supporting documentation is required.

Standard Design When the standard design has a screw chiller, the minimum part load ratio is 15%. When the standard design has a centrifugal chiller, the minimum part load ratio is 10%.

Chiller Cooling Capacity Adjustment Curve

Applicability All chillers

Definition A curve or group of curves or other functions that represent the available total cooling capacity as a function of evaporator and condenser conditions and perhaps other operating conditions. The default curves are given as follows:

$$Q_{available} = CAP\_FT \times Q_{rated} \tag{47}$$

For air-cooled chillers:

$$CAP\_FT = a + b \times t_{chws} + c \times t_{chws}^{2} + d \times t_{odb} + e \times t_{odb}^{2} + f \times t_{chws} \times t_{odb} \tag{48}$$

For water-cooled chillers:

$$CAP\_FT = a + b \times t_{chws} + c \times t_{chws}^{2} + d \times t_{cws} + e \times t_{cws}^{2} + f \times t_{chws} \times t_{cws} \tag{49}$$

Where:

$Q_{available}$	Available cooling capacity at present evaporator and condenser conditions (MBH)
t_{chws}	The chilled water supply temperature (°F)
t_{cws}	The condenser water supply temperature (°F)
t_{odb}	The outside air dry-bulb temperature (°F)
Q_{rated}	Rated capacity at AHRI conditions (MBH)

Note: If an air-cooled unit employs an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.

Separate curves are provided for Path A and Path B chillers in Appendix 5.7.

Units Data structure

Input Restrictions Prescribed curves are provided in Appendix 5.7 for the proposed design chiller type and the compliance path (Path A or Path B). If the default curves are overridden, supporting documentation is required.

Standard Design Use prescribed curve for Path B chiller as applicable to the standard design chiller type.

Electric Chiller Cooling Efficiency Adjustment Curves

Applicability All chillers

Definition A curve or group of curves that varies the cooling efficiency of an electric chiller as a function of evaporator conditions, condenser conditions and part-load ratio. Note that for variable-speed chillers, the part-load cooling efficiency curve is a function of both part-load ratio and leaving condenser water temperature. The default curves are given as follows:

(50)

$$PLR = \frac{Q_{operating}}{Q_{available}\left(t_{chws}, t_{cws/odb}\right)}$$

$$EIR\_FPLR = a + b \times PLR + c \times PLR^2$$

$$\text{variable-speed} \quad EIR\_FPLR = a + b \times PLR + c \times PLR^2 + d \times t_{cws} + e \times t_{cws}{}^2 + f \times PLR \cdot t_{cws} + g \times PLR^3$$

$$+ h \times t_{cws}{}^3 + i \times PLR^2 \cdot t_{cws} + j \times t_{cws}{}^2 \cdot PLR$$

$$\text{air-cooled} \quad EIR\_FT = a + b \times t_{chws} + c \times t_{chws}{}^2 + d \times t_{odb} + e \times t_{odb}{}^2 + f \times t_{chws} \times t_{odb}$$

$$\text{water-cooled} \quad EIR\_FT = a + b \times t_{chws} + c \times t_{chws}{}^2 + d \times t_{cws} + e \times t_{cws}{}^2 + f \times t_{chws} \times t_{cws}$$

$$P_{operating} = P_{rated} \times EIR\_FPLR \times EIR\_FT \times CAP\_FT$$

Where:

PLR	Part load ratio based on available capacity (not rated capacity)
$Q_{operating}$	Present load on chiller (Btu/h)
$Q_{available}$	Chiller available capacity at present evaporator and condenser conditions (Btu/h)
t_{chws}	The chilled water supply temperature (°F)

t_{cws}	The condenser water supply temperature (°F)
t_{odb}	The outside air dry-bulb temperature (°F)
P_{rated}	Rated power draw at AHRI conditions (kW)
$P_{operating}$	Power draw at specified operating conditions (kW)

Note: If an air-cooled chiller employs an evaporative condenser, t_{odb} is the effective dry-bulb temperature of the air leaving the evaporative cooling unit.

Units Data structure

Input Restrictions Curves are prescribed in Appendix 5.7 given the chiller capacity and type. A separate set of curves is be provided for Path A chillers and Path B chillers. The Path is determined by comparing software inputs of full-load efficiency and integrated part-load value with the requirements of Standards Table 110.2-D.

Standard Design Use Path B curves specified in Appendix 5.7.

Fuel and Steam Chiller Cooling Efficiency Adjustment Curves

Applicability All chillers

Definition A curve or group of curves that varies the cooling efficiency of a fuel-fired or steam chiller as a function of evaporator conditions, condenser conditions, and part-load ratio. The default curves are given as follows:

Default Curves for Steam-Driven Single and Double Effect Absorption Chillers

(51)

$$PLR = \frac{Q_{operating}}{Q_{available}(t_{chws}, t_{cws/odb})}$$

$$FIR\_FPLR = a + b \times PLR + c \times PLR^2$$

$$FIR\_FT = a + b \times t_{chws} + c \times t_{chws}{}^2 + d \times t_{cws} + e \times t_{cws}{}^2 + f \times t_{chws} \times t_{cws}$$

$$Fuel_{partload} = Fuel_{rated} \times FIR\_FPLR \times FIR\_FT \times CAP\_FT$$

Default Curves for Direct-Fired Double Effect Absorption Chillers

(52)

$$PLR = \frac{Q_{operating}}{Q_{available}(t_{chws}, t_{cws/odb})}$$

$$FIR\_FPLR = a + b \times PLR + c \times PLR^2$$

$$FIR\_FT1 = a + b \times t_{chws} + c \times t_{chws}{}^2$$

$$FIR\_FT2 = d + e \times t_{cws} + f \times t_{cws}{}^2$$

$$Fuel_{partload} = Fuel_{rated} \times FIR\_FPLR \times FIR\_FT1 \times FIR\_FT2 \times CAP\_FT$$

The default curves for engine driven chillers are the same format as those for the Steam-Driven Single and Double Effect Absorption Chillers but there are three sets of curves for different ranges of operation based on the engine speed.

Where:

PLR	Part load ratio based on available capacity (not rated capacity)
FIR-FPLR	A multiplier on the fuel input ratio (FIR) to account for part load conditions

FIR-FT	A multiplier on the fuel input ratio (FIR) to account for the chiller water supply temperature and the condenser water temperature
FIR-FT1	A multiplier on the fuel input ratio (FIR) to account for chilled water supply temperature
FIR-FT2	A multiplier on the fuel input ratio (FIR) to account for condenser water supply temperature
CAP-FT	A multiplier on the capacity of the chiller (see Equation (48))
$Q_{operating}$	Present load on chiller (in Btu/h)
$Q_{available}$	Chiller available capacity at present evaporator and condenser conditions (in Btu/h)
t_{chws}	The chilled water supply temperature (in °F)
t_{cws}	The condenser water supply temperature (in °F)
t_{odb}	The outside air dry-bulb temperature (°F)
$Fuel_{rated}$	Rated fuel consumption at AHRI conditions (in Btu/h)
$Fuel_{partload}$	Fuel consumption at specified operating conditions (in Btu/h)

Units	Data structure
Input Restrictions	Restricted to curves specified in Appendix 5.7.
Standard Design	Use prescribed curves specified in Appendix 5.7.

Chilled Water Supply Temperature

Applicability	All chillers
Definition	The chilled water supply temperature of the chiller at design conditions
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	The baseline chilled water supply temperature is set to 44°F.

Chilled Water Return Temperature

Applicability	All chillers
Definition	The chilled water return temperature setpoint at design conditions
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed
Standard Design	The standard design chilled water return temperature is set to 64°F.

Chilled Water Supply Temperature Control Type

Applicability	All chillers
Definition	The method by which the chilled water setpoint temperature is reset. The chilled water setpoint may be reset based on demand or outdoor air temperature.

Units	List None Outside air-based reset Demand-based reset
Input Restrictions	As designed.
Standard Design	Outside-air based reset

Chilled Water Supply Temperature Reset

Applicability	All chillers
Definition	The reset schedule for the chilled water supply temperature. The chilled water setpoint may be reset based on demand or outdoor air temperature.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed.
Standard Design	, 10°F from design chilled water supply temperature The chilled water supply temperature reset follows an outside-air reset scheme, where the setpoint is 44F at outside air conditions of 80F dry-bulb and above, the setpoint is 54F at outside air conditions of 60F dry-bulb and below, and ramps linearly from 44F to 54F as the outside air dry-bulb temperature varies between 80F and 60F.

Condenser Type

Applicability	All chillers
Definition	The type of condenser for a chiller. The choices are: • Air-Cooled • Water-Cooled • Evaporatively-Cooled Air-cooled chillers use air to cool the condenser coils. Water-cooled chillers use cold water to cool the condenser and additionally need either a cooling tower or a local source of cold water. Evaporatively-cooled chillers are similar to air-cooled chillers, except they use a water mist to cool the condenser coil which makes them more efficient.
Units	List (see above)
Input Restrictions	As designed
Standard Design	The baseline chiller is always assumed to have a water-cooled condenser, although the chiller type will change depending on the design capacity.

5.8.3 Cooling Towers

Standard Design Summary. Standard Design system 6 has one or more cooling towers. One tower is assumed to be matched to each standard design chiller. Each standard design chiller has its own condenser water pump that operates when the chiller is brought into service. The range between the condenser water return (CWR) and condenser water supply (CWS) is 10 F. The baseline building condenser pumping energy is assumed to be 12 W/gpm. The cooling tower is assumed to have a variable-speed fan that is controlled to provide a CWS equal to the design wet-bulb temperature when weather permits. The design approach shall be 10°F.

Cooling Tower Name

Applicability	All cooling towers
Definition	A unique descriptor for each cooling tower
Units	Text, unique
Input Restrictions	User entry. Where applicable, this should match the tags that are used on the plans.
Standard Design	Descriptive name that keys the baseline building plant

Cooling Tower Type

Applicability	All cooling towers
Definition	The type of cooling tower employed. The choices are: • Open tower, centrifugal fan • Open tower, axial fan Open cooling towers collect the cooled water from the tower and pump it directly back to the cooling system. Closed towers circulate the evaporated water over a heat exchanger to indirectly cool the system fluid.
Units	List (see above)
Input Restrictions	As designed
Standard Design	The baseline cooling tower is an open tower axial fan device

Cooling Tower Capacity

Applicability	All cooling towers
Definition	The tower thermal capacity per cell adjusted to CTI (Cooling Technology Institute) rated conditions of 95 °F condenser water return, 85 °F condenser water supply, and 78 °F wet-bulb with a 3 gpm/nominal ton water flow. The default cooling tower curves below are at unity at these conditions.
Units	Btu/h
Input Restrictions	As designed
Standard Design	The baseline building chiller is autosized and increased by 15%. The tower is sized to supply 85 °F condenser water at design conditions for the oversized chiller.

Cooling Tower Number of Cells

Applicability	All cooling towers
Definition	The number of cells in the cooling tower. Each cell will be modeled as equal size. Cells are subdivisions in cooling towers into individual cells, each with their own fan and water flow, and allow the cooling system to respond more efficiently to lower load conditions.
Units	Numeric: integer
Input Restrictions	As designed
Standard Design	One cell per tower and one tower per chiller.

Cooling Tower Total Fan Horse Power	
Applicability	All cooling towers
Definition	The sum of the nameplate rated horsepower (hp) of all fan motors on the cooling tower. Pony motors should not be included.
Units	Gpm/hp or unitless if energy input ratio (EIR) is specified (If the nominal tons but not the condenser water flow is specified, the condenser design water flow shall be 3.0 gpm per nominal cooling ton.)
Input Restrictions	As designed, but the cooling towers shall meet minimum performance requirements in Table 110.2-G.
Standard Design	The cooling tower fan horsepower is 60 gpm/hp.

Cooling Tower Design Wet-Bulb	
Applicability	All cooling towers
Definition	The design wet-bulb temperature that was used for selection and sizing of the cooling tower.
Units	Degrees Fahrenheit (°F)
Input Restrictions	Specified from design wet-bulb conditions from Reference Appendix JA2 for the city where the building is located, or the city closest to where the building is located.
Standard Design	Specified from design wet-bulb conditions from Reference Appendix JA2 for the city where the building is located, or from the city closest to where the building is located.

Cooling Tower Design Entering Water Temperature	
Applicability	All cooling towers
Definition	The design condenser water supply temperature (leaving tower) that was used for selection and sizing of the cooling tower.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed. Default to 85°F.
Standard Design	85°F or 10°F above the design wet-bulb temperature, whichever is lower

Cooling Tower Design Return Water Temperature	
Applicability	All cooling towers
Definition	The design condenser water return temperature (entering tower) that was used for selection and sizing of the cooling tower.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed. Default to 95°F.
Standard Design	Set to a range of 10 F (10°F above the cooling tower design entering water temperature.

Cooling Tower Capacity Adjustment Curve(s)	
Applicability	All cooling towers
Definition	A curve or group of curves that represent the available total cooling capacity as a function of outdoor air wet-bulb, condenser water supply and condenser water return temperatures. The default curves are given as follows:

Option 1 (DOE-2 based performance curves)

(53)

$$t_R = t_{cwr} - t_{cws}$$
$$t_A = t_{cws} - t_{owb}$$
$$t_A = a + b \times t_R + c \times {t_R}^2 + d \times FRA + e \times FRA^2 + f \times t_R \times FRA$$
$$FRA = \frac{-d - f \times t_R + \sqrt{(d + f \times t_R)^2 - 4 \times e \times \left(a + b \times t_R + c \times {t_R}^2 - t_A\right)}}{2 \times e}$$
$$FWB = a + b \times FRA + c \times FRA^2 + d \times t_{owb} + e \times {t_{owb}}^2 + f \times FRA \times t_{owb}$$
$$Q_{available} = Q_{rated} \times FWB \times \left(\frac{t_R}{10}\right)$$

Where:

$Q_{available}$	Available cooling capacity at present outside air and condenser water conditions (MBH)
Q_{rated}	Rated cooling capacity at CTI test conditions (MBH)
t_{cws}	The condenser water supply temperature (in °F)
t_{cwr}	The condenser water return temperature (in °F)
t_{owb}	The outside air wet-bulb temperature (°F)
t_R	The tower range (in °F)
t_A	The tower approach (in °F)
FRA	An intermediate capacity curve based on range and approach
FWB	The ratio of available capacity to rated capacity (gpm/gpm).

Option 2: CoolTools performance curve (EnergyPlus)

Approach = Coeff(1) + Coeff(2)•FRair + Coeff(3)•$(FRair)^2$ +Coeff(4)•$(FRair)^3$ + Coeff(5)•FRwater + Coeff(6)•FRair•FRwater + Coeff(7)•$(FRair)^2$•FRwater + Coeff(8)•$(FRwater)^2$ + Coeff(9)•FRair•$(FRwater)^2$ + Coeff(10)•$(FRwater)^3$ + Coeff(11)•Twb + Coeff(12)•FRair•Twb + Coeff(13)•$(FRair)^2$•Twb + Coeff(14)•FRwater•Twb + Coeff(15)•FRair•FRwater•Twb + Coeff(16)•$(FRwater)^2$•Twb + Coeff(17)•$(Twb)^2$ + Coeff(18)•FRair•$(Twb)^2$ + Coeff(19)•FRwater•$(Twb)^2$ + Coeff(20)•$(Twb)^3$ + Coeff(21)•Tr + Coeff(22)•FRair•Tr + Coeff(23)•FRair•FRair•Tr + Coeff(24)•FRwater•Tr + Coeff(25)•FRair•FRwater•Tr + Coeff(26)•$(FRwater)^2$•Tr + Coeff(27)•Twb•Tr + Coeff(28)•FRair•Twb•Tr + Coeff(29)•FRwater•Twb•Tr + Coeff(30)•$(Twb)^2$•Tr + Coeff(31)•$(Tr)^2$ + Coeff(32)•FRair•$(Tr)^2$ + Coeff(33)•FRwater•$(Tr)^2$ + Coeff(34)•Twb•$(Tr)^2$ + Coeff(35)•$(Tr)^3$

Where:

FRair – ratio of airflow to airflow at design conditions

FRwater – ratio of water flow to water flow at design conditions

Tr – tower range (deg F)

Twb – wet-bulb temperature

Coefficients for this performance curve are provided in Appendix 5.7.

	Data structure
Input Restrictions	User may only use one of the two curves specified in Appendix 5.7.
Standard Design	Use one of the prescribed curves defined in Appendix 5.7.

Cooling Tower Set Point Control

Applicability All cooling towers

Definition The type of control for the condenser water supply. The choices are:

- Fixed
- Wet-bulb reset

A fixed control will modulate the tower fans to provide the design condenser water supply temperature at all times when possible. A wet-bulb reset control will reset the condenser water setpoint to a fixed approach to outside air wet-bulb temperature. The approach defaults to 10°F. A lower approach may be used with appropriate documentation.

Units List (see above)

Input Restrictions As designed. If the design includes a waterside economizer, the tower fans run at 100% speed whenever the WSE is enabled.

Standard Design Fixed at the 0.4% design wet-bulb temperature, which is prescribed and specified for each of the 86 weather data files

Cooling Tower Capacity Control

Applicability All cooling towers

Definition Describes the modulation control employed in the cooling tower. Choices include:

- **Fluid Bypass** provides a parallel path to divert some of the condenser water around the cooling tower at part-load conditions
- **Fan Cycling** is a simple method of capacity control where the tower fan is cycled on and off. This is and is often used on multiple-cell installations.
- **Two-Speed Fan/Pony Motor**. From an energy perspective, these are the same. A lower horsepower pony motor is an alternative to a two-speed motor; the pony motor runs at part-load conditions (instead of the full sized motor) and saves fan energy when the tower load is reduced. Additional building descriptors are triggered when this method of capacity control is selected.
- **Variable Speed Fan.** A variable frequency drive is installed for the tower fan so that the speed can be modulated.

Units List (see above)

Input Restrictions As designed.

Standard Design Variable-speed fan

Cooling Tower Low-Speed Airflow Ratio

Applicability All cooling towers with two-speed or pony motors

Definition The percentage full load airflow that the tower has at low speed or with the pony motor operating. This is equivalent to the percentage full load capacity when operating at low speed.

Units	Ratio
Input Restrictions	As designed.
Standard Design	Not applicable

Cooling Tower Low-Speed kW Ratio

Applicability	All cooling towers with two-speed or pony motors
Definition	The percentage full load power that the tower fans draw at low speed or with the pony motor operating
Units	Ratio
Input Restrictions	Calculated, using the as-designed flow ratio and the cooling tower power adjustment curve below..
Standard Design	Not applicable

Cooling Tower Power Adjustment Curve

Applicability All cooling towers with VSD control

Definition A curve that varies the cooling tower fan energy usage as a function of part-load ratio for cooling towers with variable speed fan control. The default curve is given as follows:

(54)

$$PLR = \frac{Q_{operating}}{Q_{available}(t_R, t_A, t_{OWB})}$$

$$TWR\_FAN\_FPLR = a + b \times PLR + c \times PLR^2 + d \times PLR^3$$

$$P_{operating} = P_{rated} \times TWR\_FAN\_FPLR$$

Where:

PLR	Part load ratio based on available capacity (not rated capacity)
$Q_{operating}$	Present load on tower (in Btu/h)
$Q_{available}$	Tower available capacity at present range, approach, and outside wet-bulb conditions (in Btu/h).
t_{owb}	The outside air wet-bulb temperature (°F)
t_R	The tower range (°F)
t_A	The tower approach (°F)
P_{rated}	Rated power draw at CTI conditions (kW)
$P_{operating}$	Power draw at specified operating conditions (kW)

Table 51 – Default Efficiency TWR-FAN-FPLR Coefficients – VSD on Cooling Tower Fan

Coefficient	TWR-FAN-FPLR
A	0.33162901
B	-0.88567609
C	0.60556507
D	0.9484823

Units Data structure

Input Restrictions User shall use only default curves.

Standard Design Use default curves given above.

Cooling Tower Minimum Speed

Applicability All cooling towers with a VSD control

Definition The minimum fan speed setting of a VSD controlling a cooling tower fan expressed as a ratio of full load speed.

Units Ratio

Input Restrictions As designed. The default is 0.50.

Standard Design 0.5

5.8.4 Water-side Economizers

Baseline Building Summary. None of the baseline building systems use a water-side economizer.

Water-Side Economizer Name

Applicability All water-side economizers

Definition The name of a water-side economizer for a cooling system

Units Text, unique

Input Restrictions Descriptive reference to the construction documents. The default is no water-side economizer.

Standard Design No water economizer

Water Economizer Type

Applicability All water-side economizers

Definition The type of water-side economizer. Choices include:

- None
- Heat exchanger in parallel with chillers. This would be used with an open cooling tower is often referred to as a non-integrated economizer, because the chillers are locked out when the plant is in economizer mode.
- Heat exchanger in series with chillers. This would be used with an open cooling tower and is often referred to as an integrated, because the chillers can operate simultaneously with water economizer operation.

Units List (see above)

Input Restrictions As designed

Standard Design	No water economizer

Water-Side Economizer Heat Exchanger Capacity

Applicability	Water-side economizers with an open cooling tower
Definition	The heat removal capacity of the water-side economizer at design conditions, at 50F DB, 45F WB, tested to AHRI 400.
Units	Btu/h
Input Restrictions	As designed. *(no default value – required field if WSE is present)*
Standard Design	Not applicable

Water-Side Economizer CW Supply Temperature

Applicability	All water-side economizers
Definition	The design temperature of the water entering the heat exchanger supplied by the tower or WSE.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed. Defaults to 45F.
Standard Design	No water economizer

Water-Side Economizer CW Return Temperature

Applicability	All water-side economizers
Definition	The design temperature of the water leaving the heat exchanger on the supply side (condenser water side).
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed. Defaults to 55F.
Standard Design	No water economizer

Water-Side Economizer CHW Supply Temperature

Applicability	All water-side economizers
Definition	The design temperature of the water leaving the load side of the heat exchanger, to the chiller when run in series or to the load when run in parallel (non-integrated).
Units	Degrees Fahrenheit (°F)
Input Restrictions	As Designed. Defaults to 48F.
Standard Design	No water economizer

Water-Side Economizer CHW Return Temperature

Applicability	All water-side economizers
Definition	The design temperature of the water entering the load side of the heat exchanger.
Units	Degrees Fahrenheit (°F)
Input Restrictions	As designed. Defaults to 60F.
Standard Design	

No water economizer

Water-Side Economizer Control Differential

Applicability All water-side economizers

Definition The minimum temperature difference between the supply entering stream and demand (load) exiting stream required to enable the waterside economizer.

Units Degrees Fahrenheit (°F)

Input Restrictions 2 degrees F (not user editable).

Standard Design No water economizer

Water-Side Economizer Auxiliary kW

Applicability Water-side economizers with an open tower

Definition The electrical input (pumps and auxiliaries) for a dedicated pump for the chilled water side of the heat exchanger. This power is in excess of the condenser water pumps and cooling tower fans for the system during water-side economizer operation.

Units kW

Input Restrictions As designed

Standard Design No water economizer

5.8.5 Pumps

Baseline Building Summary. Hot water pumping in the baseline building shall be modeled as a variable flow primary only system. Two-way valves are assumed at the heating coils.

Chilled water pumping in the baseline building (system 6) is a primary system. Each chiller has its own primary and condenser water pumps that operate when the chiller is activated. For plants less than or equal to 300 tons, the secondary pump “rides the curve” for larger plants, the pump has a variable speed drive. The chilled water pump shall be variable speed and the condenser water pump shall be fixed speed.

General Notes. The building descriptors in this section are repeated for each pumping system. See the Pump Service building descriptor for a list of common pump services.

Pump Name

Applicability All pumps

Definition A unique descriptor for each pump

Units Text, unique

Input Restrictions User entry. Where applicable, this should match the tags that are used on the plans.

Standard Design Same as the proposed design. If there is no equivalent in the proposed design, assign a sequential tag to each piece of equipment. The sequential tags should indicate the pump service as part of the descriptor (e.g. CW for condenser water, CHW for chilled water, or HHW for heating hot water).

Pump Service

Applicability	All pumps
Definition	The service for each pump. Choices include: • Chilled water • Chilled water (primary) • Chilled water (secondary) • Heating water • Heating water (primary) • Heating water (secondary) • Service hot water • Condenser water • Loop water (for hydronic heat pumps)
Units	List (see above)
Input Restrictions	As designed
Standard Design	As needed by the baseline building system

Number of Pumps

Applicability	All pumps
Definition	The number of identical pumps in service in a particular loop, e.g. the heating hot water loop, chilled water loop, or condenser water loop
Units	Numeric: integer
Input Restrictions	As designed
Standard Design	There will be one heating hot water pump for each boiler, one chilled water pump, and one condenser water pump for each chiller.

Water Loop Design

Applicability	All pumps
Definition	The heating and cooling delivery systems can consist of a simple primary loop system, or more complicated primary/secondary loops or primary/secondary/tertiary loops.
Units	List (see above)
Input Restrictions	As designed
Standard Design	Assume primary loops only for heating hot water. For chilled water loops, a primary loop design is assumed.

Pump Motor Modeling Method	
Applicability	All pumps
Definition	Software commonly models fans in one of two ways: The simple method is for the user to enter the electric power per unit of flow (W/gpm). This method is commonly used for smaller systems. A more detailed method requires a specification of the pump head, design flow, impeller and motor efficiency.
Units	List: Power-Per-Unit-Flow or Detailed
Input Restrictions	Detailed
Standard Design	Detailed for Chilled Water and Condenser Water Pumps; Power-per-unit-flow for Heating hot water and Service hot water pumps

Pump Motor Power-Per-Unit-Flow	
Applicability	All proposed design pumps that use the Power-Per-Unit-Flow method.
Definition	The electric power of the pump divided by the flow at design conditions.
Units	W/gpm
Input Restrictions	As designed
Standard Design	Not applicable for chilled water and condenser water pumps; 19 W/gpm for heating hot water and service hot water pumps

Pump Motor Horsepower	
Applicability	All pumps
Definition	The nameplate motor horsepower
Units	horsepower
Input Restrictions	Constrained to be a value from the following list of standard motor sizes: A Standard Motor Size table (hp) is defined as: 1/12, 1/8, ¼, ½, ¾, 1, 1.5, 2, 3, 5, 7.5, 10, 15, 20, 25, 30, 40, 50, 60, 75, 100, 125, 150, 200
Standard Design	Not applicable

Pump Design Head	
Applicability	All baseline building pumps and proposed design pumps that use the Detailed method.
Definition	The head of the pump at design flow conditions.
Units	ft of w.g.
Input Restrictions	As designed, but subject to an input restriction. The user inputs of Pump Design Head, Impeller Efficiency and Cooling Tower Design Entering Water Temperature and Cooling Tower Design Return Water Temperature shall be used to calculate the proposed brake horsepower. This shall be compared to the Pump Motor Horsepower for the next smaller motor size (MHP_{i-1}) than the one specified by the user (MHP_i). The Proposed Design Pump Design Head shall be constrained so that the resulting brake horsepower is no smaller than 95% of the next smaller motor size: Proposed Design bhp = max(Proposed Design bhp_{user_head}, 0.95 x MHPi-1) Where Proposed Design bhp – is the brake horsepower used in the simulation

Proposed Design bhp_{user_head} = the brake horsepower resulting from the user input of design head

MHPi = the Pump Motor Horsepower specified by the user

i = the index into the Standard Motor Size table for the user motor horsepower

MHPi-1 = the motor horsepower for the next smaller motor size. For example, if the user-specified Pump Motor Horsepower is 25, the next smaller motor size in the table above is 20.

Since all other user inputs that affect the proposed design brake horsepower are not modified, the Proposed Design Pump Design Head is adjusted in the same proportion as the pump brake horsepower in the equation above. If the user-entered Pump Design Head results in a brake horsepower that is at least 95% of the horsepower of the next smaller motor size, no modification of the user input is required.

Standard Design For chilled water pumps, 40 ft plus an additional allowance of 0.03 ft/ton, but not to exceed 100 ft

For condenser water pumps, 45 ft

Impeller Efficiency

Applicability All pumps in proposed design that use the detailed modeling method

Definition The full load efficiency of the impeller

Units Ratio

Input Restrictions As designed

Standard Design Not applicable

Motor Efficiency

Applicability All pumps in proposed design that use the detailed modeling method

Definition The full load efficiency of the pump motor

Units Ratio

Input Restrictions As designed

Standard Design Not applicable T Table 31, using the next larger motor size than the calculated Standard Design brake horsepower.

Pump Minimum Speed

Applicability All two-speed or variable-speed pumps

Definition The minimum pump speed for a two-speed for variable-speed pump. For two-speed pumps this is typically 0.67 or 0.5. Note that the pump minimum speed is not necessarily the same as the minimum flow ratio, since the system head may change.

Units Ratio

Input Restrictions As designed

Standard Design 0.10.

Pump Minimum Flow Ratio

Applicability Primary Chilled water pumps

Definition	The minimum fraction of design flow when the pump is operating at its minimum speed. Note that the pump minimum speed is not necessarily the same as the minimum flow ratio, since the system head may change.
Units	Ratio
Input Restrictions	As designed
Standard Design	0.3

Pump Design Flow (GPM)

Applicability	All pumps
Definition	The flow rate of the pump at design conditions. This is derived from the load, and the design supply and return temperatures.
Units	gpm or gpm/ton for condenser and primary chilled water pumps
Input Restrictions	Not a user input
Standard Design	The temperature change on the evaporator side of the chillers is 20 F (64 F less 44 F) and this equates to a flow of 1.2 gpm/ton. The temperature change on the condenser side of the chillers is 12 F, which equates to a flow of 2.0 gpm/ cooling ton. A VSD is required for heating pumps when the service area is greater than or equal to 120,000 ft². For hot water pumps servicing boilers, the flow rate in gpm shall correspond to a loop temperature drop of 40°F.

Pump Control Type

Applicability	All pumps
Definition	The type of control for the pump. Choices are: • Fixed speed, fixed flow • Fixed speed, variable flow (the default, with flow control via a valve) • Two-speed • Variable speed, variable flow
Units	None
Input Restrictions	As designed. The default is “Fixed Speed, Variable Flow” which models the action of a constant speed pump riding the curve against 2-way control valves.
Standard Design	The chilled water pumping for systems 7 and 8 is primary/secondary with variable flow. When the chilled water system has a capacity of less than 300 tons, the secondary system pumps shall ride the pump curve. When the chilled water system has a capacity of more than 300 tons, the secondary chilled water pumps shall be variable speed. Chilled water pumps used in the primary loop shall be fixed speed, fixed flow. Condenser water pumps shall be modeled as fixed speed, fixed flow. The chilled water pumps shall be modeled as variable-speed, variable flow, and the condenser water pumps shall be modeled as fixed speed. The hot water pumps shall be modeled as fixed-speed, variable flow, riding the curve.

Pump Operation

Applicability	All pumps
Definition	The type of pump operation can be either On-Demand, Standby or Scheduled. On-Demand operation means the pumps are only pumping when their associated

equipment is cycling, so chiller and condenser pumps are on when the chiller is on and the heating hot water pump operates when its associated boiler is cycling. Standby operation allows hot or chilled water to circulate through the primary loop of a primary/secondary loop system or through a reduced portion of a primary-only system, assuming the system has appropriate 3-way valves. Scheduled operation means that the pumps and their associated equipment are turned completely off according to occupancy schedules, time of year, or outside conditions. Under scheduled operation, when the systems are on they are assumed to be in On-Demand mode.

Units List (see above)

Input Restrictions As designed

Standard Design The baseline system pumps are assumed to operate in On-Demand mode. The chilled water and condenser pumps are tied to the chiller operation, cycling on and off with the chiller, and the heating hot water pumps are tied to the boiler operation.

Pump Part Load Curve

Applicability All pumps

Definition A part-load power curve for the pump

(55)

$$CIRC-PUMP-FPLR = a + b \times PLR + c \times PLR^2 + d \times PLR^3$$

(56)

$$P_{pump} = P_{design} \times CIRC-PUMP-FPLR$$

Where:

PLR	Part load ratio (the ratio of operating flow rate in gpm to design flow rate in gpm)
P_{pump}	Pump power draw at part-load conditions (W)
P_{design}	Pump power draw at design conditions (W)

Table 52 – Default Part-Load CIRC-PUMP-FPLR Coefficients – VSD on Circulation Pump

Coefficient	Default (No Reset)	DP Reset
a	0	0
b	0.5726	0.0205
c	-0.301	0.4101
d	0.7347	0.5753

Source:

Units Data structure

Input Restrictions Default is *Default (No Reset)*. The *DP Reset* curve may only be selected if the DDC Control Type building descriptor indicates that the building has DDC controls.

Standard Design *DP Reset* curve for chilled water pumps. Heating Hot water pump power is assumed to be constant even though the pump is riding the curve.

5.8.6 Thermal Storage

There are multiple ways to model thermal storage in the proposed design. The baseline building does not have thermal storage. Stratified storage tanks with a chilled water storage medium are not supported by the ACM.

Storage Type	
Applicability	All thermal storage systems
Definition	A type of thermal energy storage (TES) that indicates the storage medium.
Units	List
Input Restrictions	Ice, Chilled Water
Standard Design	No thermal storage systems

Configuration	
Applicability	All thermal storage systems
Definition	Indication of how the TES is configured and operated in relation to the chilled water cooling
Units	List
Input Restrictions	Series, Chiller Upstream Series, Chiller Downstream Parallel
Standard Design	No thermal storage systems

Ice Storage Type	
Applicability	All thermal storage systems with Storage Type=Ice
Definition	Indication of the storage type for ice storage
Units	List
Input Restrictions	IceOnCoilExternal IceOnCoilInternal
Standard Design	No thermal storage systems

Storage Capacity	
Applicability	All thermal storage systems using ice storage
Definition	Nominal Storage Capacity of the tank
Units	GJ
Input Restrictions	None
Standard Design	No thermal storage systems

Tank Volume	
Applicability	All thermal storage systems using ice storage
Definition	Nominal Storage Capacity of the tank
Units	m^3
Input Restrictions	None
Standard Design	No thermal storage systems

CHW Setpoint Schedule	
Applicability	All thermal storage systems using ice storage
Definition	Nominal Storage Capacity of the tank
Units	Series, deg F
Input Restrictions	None
Standard Design	No thermal storage systems

Deadband Temperature Difference	
Applicability	All thermal storage systems using chilled water
Definition	The deadband temperature difference between enabling and disabling use of the TES system for cooling
Units	Degrees F
Input Restrictions	None
Standard Design	No thermal storage systems

Minimum Temperature Limit	
Applicability	All thermal storage systems using chilled water
Definition	The minimum allowed temperature of the tank, below which charging of the tank cannot occur
Units	Deg F
Input Restrictions	None
Standard Design	No thermal storage systems

Storage Tank Location Indicator	
Applicability	All thermal storage systems using ice storage
Definition	Nominal Storage Capacity of the tank
Units	List
Input Restrictions	Schedule, Zone, or Exterior. If *Schedule*, the ambient temperature schedule must be specified. If *Zone*, the Zone name must be specified.
Standard Design	No thermal storage systems

Storage Tank Heat Gain Coefficient

Applicability	All thermal storage systems using chilled water
Definition	The heat transfer coefficient between the tank and the ambient surroundings
Units	W/K
Input Restrictions	None
Standard Design	No thermal storage systems

Use Side Heat Transfer Effectiveness

Applicability	All thermal storage systems using chilled water
Definition	The heat transfer effectiveness between the use side water and the tank water
Units	none
Input Restrictions	Between 0 and 1
Standard Design	No thermal storage systems

Use Side Design Flow Rate

Applicability	All thermal storage systems using chilled water
Definition	Design flow rate through the use side of the storage tank
Units	gpm
Input Restrictions	None
Standard Design	No thermal storage systems

Source Side Heat Transfer Effectiveness

Applicability	All thermal storage systems using chilled water
Definition	The heat transfer effectiveness between the source side water and the tank water
Units	none
Input Restrictions	Between 0 and 1
Standard Design	No thermal storage systems

Source Side Design Flow Rate

Applicability	All thermal storage systems using chilled water
Definition	Design flow rate through the source side of the storage tank
Units	gpm
Input Restrictions	None
Standard Design	No thermal storage systems

Tank Recovery Time	
Applicability	All thermal storage systems using ice storage
Definition	This is the time in hours for the tank to cool from 14.4°C to 9°C. This input is only used if the source side design flow rate is not specified.
Units	hours
Input Restrictions	None
Standard Design	No thermal storage systems

5.8.7 Heat Recovery Equipment

Heat Recovery Name	
Applicability	All heat recovery systems
Definition	A name assigned to a heat recovery system. This would provide a link to the construction documents.
Units	Text, unique
Input Restrictions	As designed
Standard Design	No heat recovery systems

Heat Recovery Device Type	
Applicability	All heat recovery systems
Definition	The type of heat recovery equipment. Choices include: • Double-Bundled Chiller • Generator • Engine-Driven Chiller • Air Conditioning Unit • Refrigerated Casework
Units	List (see above)
Input Restrictions	As designed
Standard Design	Heat recovery systems are not included in the baseline system.

Heat Recovery Loads	
Applicability	All heat recovery systems
Definition	The loads met by the heat recovery system. Choices include: • Service water heating • Space heating • Process heating More than one load may be selected.

Units	List (see above)
Input Restrictions	As designed
Standard Design	Not required in the baseline system.

5.8.8 Plant Management

Plant management is a method of sequencing equipment. Separate plant management schemes may be entered for chilled water systems, hot water systems, etc. The following building descriptors are specified for each load range, e.g. when the cooling load is below 300 tons, between 300 tons and 800 tons, and greater than 800 tons.

Equipment Type Managed

Applicability All plant systems

Definition The type of equipment under a plant management control scheme. Choices include:

- Chilled water cooling
- Hot water space heating
- Condenser water heat rejection
- Service water heating
- Electrical generation

Units None

Input Restrictions As designed

Standard Design Same as the proposed design

Equipment Schedule

Applicability	All plant equipment
Definition	A schedule which identifies when the equipment is in service.
Units	Data structure
Input Restrictions	As designed
Standard Design	Where multiple equipment is used, they shall be staged in operation.

Equipment Operation

Applicability	All plant equipment
Definition	Equipment operation can be either On-Demand or Always-On. On-Demand operation means the equipment cycles on when it is scheduled to be in service and when it is needed to meet building loads, otherwise it is off. Always-On means that equipment runs continuously when it scheduled to be in service.
Units	None
Input Restrictions	As designed; the default is On-Demand.
Standard Design	Assume On-Demand operation

Equipment Staging Sequence	
Applicability	All plant equipment
Definition	The staging sequence for plant equipment (chillers and boilers) indicates how multiple equipment will be staged on and off when a single piece of equipment is unable to meet the load.
Units	Structure – this should include (a) the percent of capacity above which additional equipment is staged on; (b) the percent of capacity below which one plant equipment is staged off
Input Restrictions	As designed.
Standard Design	Compliance software shall bring up each boiler to 90 percent capacity prior to the staging of the next boiler. Compliance software shall bring up each chiller to 90 percent capacity prior to the staging of the next chiller.

5.9 Miscellaneous Energy Uses

Miscellaneous energy uses are defined as those that may be treated separately since they have little or no interaction with the conditioned thermal zones or the HVAC systems that serve them.

5.9.1 Water Heating

When the construction documents show a water heating system, the layout and configuration of the baseline building system shall be the same as the proposed design, e.g. the baseline building shall have the same number of water heaters and the same distribution system.

5.9.1.1 System Loads and Configuration

Water Heating System Name	
Applicability	All water heating systems
Definition	A unique descriptor for each water heating system. A system consists of one or more water heaters, a distribution system, an estimate of hot water use, and a schedule for that use. Nonresidential buildings will typically have multiple systems, perhaps a separate electric water heater for each office break room, etc. Other building types such as hotels and hospitals may have a single system serving the entire building.
Units	Text, unique
Input Restrictions	Where applicable, this should match the tags that are used on the plans such that a plan reviewer can make a connection.
Standard Design	The naming convention for the baseline building system shall be similar to the proposed design.

Water Heating Peak Use

Applicability	All water heating systems, required
Definition	An indication of the peak hot water usage (e.g. service to sinks, showers, and kitchen appliances, etc.). When specified per occupant, this value is multiplied by design occupancy density values and modified by service water heating schedules to obtain hourly load values which are used in the simulation. Peak consumption is commonly specified as gallons per hour per occupant, dwelling unit, hotel room, patient room, or floor area. If consumption is specified in gallons per hour, then additional inputs would be needed such as supply temperature, cold water inlet temperature, etc. Software that specifies peak use as a thermal load in Btu/h. can apply ACM rules for the mains (cold water inlet) temperature and supply temperature to convert the prescribed peak use from gph/person to Btu/h-person. The thermal load does not include conversion efficiencies of water heating equipment.
Units	gph/person
Input Restrictions	Prescribed values from Appendix 5.4A if a service hot water heating system is installed; otherwise, all values are 0.
Standard Design	Prescribed values from Appendix 5.4A if a service hot water heating system is installed; otherwise, all values are 0.

Water Heating Schedule

Applicability	All water heating systems
Definition	A fractional schedule reflecting the time pattern of water heating use. This input modifies the water heating peak use, described above.
Units	Data structure: schedule, fractional
Input Restrictions	The schedules from Appendix 5.4A shall be used.
Standard Design	The schedules from Appendix 5.4A shall be used.

Water Heating System Configuration

Applicability	All water heating systems
Definition	The configuration and layout of the water heating system, including the number of water heaters; the size, location, length and insulation of distribution pipes; recirculation systems and pumps; and any other details about the system that would affect the energy model.
Units	Data structure
Input Restrictions	None
	The baseline building shall have one gas storage water heater, except for high-rise residential buildings, which shall have a gas, instantaneous water heater for each residential living space, and shall have a non-recirculating gas storage water heater for all other spaces (common areas of high-rise residential buildings and hotels).Water Mains Temperature Schedule
Applicability	All water heating systems
Definition	A monthly temperature schedule indicating the water mains temperature. This temperature and the setpoint temperature is used to convert the load into a water flow rate.

Units Data structure: schedule, deg F

Input Restrictions The schedules from Appendix 5.4A shall be used. The water mains temperature schedule shall be fixed for a given climate zone.

Standard Design The schedules from Appendix 5.4A shall be used. The water mains temperature schedule shall be fixed for a given climate zone.

5.9.1.2 Water Heaters

This section describes the building descriptors for water heaters. Typically, a building will have multiple water heating systems and each system can have multiple water heaters, so these building descriptors may need to be specified more than once.

Water Heater Name

Applicability All water heaters

Definition A unique descriptor for each water heater in the system. Some systems will have multiple pieces of equipment, for instance a series of water heaters plumbed in parallel or a boiler with a separate storage tank.

Units Text, unique

Input Restrictions Where applicable, this should match the tags that are used on the plans such that a plan reviewer can make a connection.

Standard Design The naming convention for the baseline building system shall be similar to the proposed design.

Water Heater Type and Size

Applicability All water heaters when the proposed design has a service water heating system

Definition This building descriptor includes information needed to determine the criteria from baseline standards. The choices and the associated rated capacity (heat input rate) are listed below.

- Electric water heaters (storage and instantaneous)
  - Small (≤ 12 kW)
  - Large (> 12 kW)
  - Heat pump
- Gas storage water heaters
  - Small (≤ 75,000 Btu/h)
  - Large (> 75,000 Btu/h)
- Gas instantaneous water heaters
  - Small (> 50,000 and < 200,000 Btu/h)
  - Large (≥ 200,000 Btu/h), <10 gal
  - Large (≥ 200,000 Btu/h), ≥10 gal
- Oil storage water heaters
  - Small (≤ 105,000 Btu/h)
  - Large (> 105,000 Btu/h)

- Oil instantaneous water heaters
  - o Small (≤ 210,000 Btu/h)
  - o Large (> 210,000 Btu/h), <10 gal
  - o Large (> 210,000 Btu/h), ≥ 10 gal
- Gas hot water supply boiler
- Oil hot water supply boiler

Units List (see above)

Input Restrictions As designed

Standard Design Gas storage water heater for non-residential buildings; gas instantaneous water heaters for residential living spaces of high-rise residential buildings and hotel/motel guestrooms; gas storage water heater for common spaces of high-rise residential buildings and hotel/motel buildings or for all other spaces in mixed use buildings.

Rated Capacity

Applicability All water heaters when the proposed design has a service water heating system

Definition The heating capacity of a water heater (input rate) at the rated conditions specified in DOE 10 CFR Part 430 or ANSI Z21.10.

Units Thousands of British Thermal Units per hour (MBH)

Input Restrictions As designed. If the loads are not met, the user has an option to specify an Exceptional Condition if the as-designed loads are significantly smaller than the load assumptions defined in the ACM Reference Manual for the specified space types..

Standard Design Autosize if the Exceptional Condition above is not checked. If the Exceptional Condition is checked or enabled, then the standard design capacity equals 60% of the total proposed design capacity (combined rated capacity, converted to gph, and storage capacity in gallons).

Storage Volume

Applicability Gas-fired water heaters

Definition The storage volume of a gas-fired water heater. This is used in the Standby loss calculations and baseline calculations of Energy Factor.

Units gallons

Input Restrictions As designed. If the loads are not met, the user has an option to specify an Exceptional Condition if the as-designed loads are significantly smaller than the load assumptions defined in the ACM Reference Manual for the specified space types..

Standard Design Autosize if the Exceptional Condition is not checked or enabled. If the Exceptional Condition is checked, the compliance software shall size the storage tank to 40% of the proposed total rated capacity and storage volume for the peak hour, in gallons

Energy Factor

Applicability Equipment covered by NAECA, which includes small storage and instantaneous water heaters

Definition The energy factor (EF) is the ratio of the energy delivered by the water heater divided by the energy used, in the same units. EF is calculated according to the DOE 10 CFR Part 430 test procedure, which specifies a 24-hour pattern of draws, a storage temperature, inlet water temperature, and other test conditions. These conditions result in the energy delivered for the test period. Energy inputs are measured for the same test period and the EF ratio is calculated.

Units Unitless ratio

Input Restrictions Building descriptors for the proposed design should be consistent with equipment specified on the construction documents or observed in the candidate building.

Standard Design The EF for the baseline building system shall be determined from the CEC Appliance Efficiency Regulations. The following baseline EF applies for water heaters:

Gas-fired storage type water heaters: 0.67 – 0.0019 x V

Oil-fired water heaters: 0.59 – 0.0019 x V

Electric storage water heaters: 0.97 – 0.00132 x V

Gas-fired instantaneous: 0.62 – 0.0019 x V

Electric instantaneous: 0.93 – 0.00132 x V

Heat pump water heaters: 0.97 – 0.00132 x V

Where V is the rated volume in gallons.

Thermal Efficiency

Applicability Oil and gas fired water heaters not covered by NAECA

Definition The full load efficiency of a water heater at rated conditions expressed as a dimensionless ratio of output over input. This is also referred to as recovery efficiency.

Units Unitless ratio

Input Restrictions Building descriptors for the proposed design should be consistent with equipment specified on the construction documents or observed in the candidate building.

For NAECA covered water heaters that have specified an Energy Factor but not a recovery efficiency, the default recovery efficiency is as follows:

Gas Water Heaters: $\eta_{th} = 0.78$

Electric Water Heaters: $\eta_{th} = 0.97$

Standard Design

Tank Standby Loss

Applicability Water heaters not covered by NAECA

Definition The tank standby loss for storage tanks, which includes the effect of recovery efficiency.

Units Btu/h for the entire tank

Input Restrictions Standby loss is calculated by the following:

$$STBY = 453.75 \times S \times VOL$$

Where:

S = The standby loss fraction listed in the Commission's Appliance Database of Certified Water Heaters,

VOL = The actual storage capacity of the water heater as listed in the Commission's Appliance Database of Certified Water Heaters (gallons)

Standard Design

Tank Off-Cycle Loss Coefficient

Applicability	Water heaters
Definition	The tank standby loss coefficient (UA) for the water heater. For small water heater covered by NAECA, the loss coefficient is a derived parameter, a function of the Energy Factor and recovery efficiency
Units	Btu/h-deg F
Input Restrictions	For NAECA covered water heaters, the loss coefficient is calculated by the following:

$$UA = \frac{1/EF - 1/RE}{67.5 \times \left(\frac{24}{41094} - \frac{1}{RE \cdot Pon}\right)}$$

Where:

EF = The energy factor of the rated water heater (Unitless)

RE = The recovery efficiency of the rated water heater. If this data is not available the default shall be 0.78 for gas water heaters and 0.93 for electric water heaters.

Pon = The input power to the water heater, in Btu/h

Standard Design

Off Cycle Parasitic Losses

Applicability	Water heater
Definition	The rate of parasitic losses, such as a pilot light or controls, when the water heater is not heating.
Units	Watts
Input Restrictions	As designed
Standard Design	0

Off Cycle Fuel Type

Applicability	Water heater
Definition	The type of fuel that serves energy using parasitic equipment, such as a pilot light or controls, when the water heater is not heating.
Units	List: Electricity, Gas, Oil, Propane
Input Restrictions	As designed
Standard Design	Not applicable

On Cycle Parasitic Losses

Applicability	Water heater
Definition	The rate of parasitic losses, such as a pilot light or controls, when the water heater is not heating. This may be different than off cycle losses if the flue energy is considered.
Units	Watts
Input Restrictions	As designed
Standard Design	Not applicable

On Cycle Fuel Type	
Applicability	Water heater
Definition	The type of fuel that serves energy using parasitic equipment, such as a pilot light or controls, when the water heater is not heating.
Units	List: Electricity, Gas, Oil, Propane
Input Restrictions	As designed
Standard Design	Electricity

Water Heater Ambient Location	
Applicability	Water heater
Definition	The location of the water heater for determining losses and energy interaction with the surroundings
Units	List: Schedule, Zone, Outdoors
Input Restrictions	As designed
Standard Design	Not applicable

Tank Standby Loss Fraction	
Applicability	Title 24 Standards
Definition	The tank standby loss fraction for storage tanks.
Units	Unitless
Input Restrictions	Prescribed to the value listed in the Commission's Appliance Database of Certified Water Heaters
Standard Design	Not applicable

THE PART-LOAD CURVE PROCEDURE IN TITLE 24 CAN BE AN ALTERNATE METHOD OF SPECIFYING THE EFFECTS OF STANDBY AND PARASITIC LOSSES ON PERFORMANCE. THE PRIMARY METHOD IS TO SPECIFY A LOSS COEFFICIENT FOR THE STORAGE TANK.

Fuel Water Heater Part Load Efficiency Curve	
Applicability	Water Heating equipment for which a loss coefficient is not specified (alternate method)
Definition	A set of factors that adjust the full-load thermal efficiency for part load conditions. The factor is set as a curve.
Units	Percent (%)
Input Restrictions	The following prescribed curve shall be used based on user inputs. The curve shall take the form of a quadratic equation as follows:

(57)

$$Fuel_{partload} = Fuel_{design} \times FHeatPLC$$

$$FHeatPLC = \left(a + b \times \frac{Q_{partload}}{Q_{rated}} \right)$$

Where:

FHeatPLC	The fuel heating part load efficiency curve
$Fuel_{partload}$	The fuel consumption at part load conditions (Btu/h)
$Fuel_{design}$	The fuel consumption at design conditions (Btu/h)
$Q_{partload}$	The water heater capacity at part load conditions (Btu/h)
Q_{rated}	The water heater capacity at design conditions (Btu/h)

For Title 24, the coefficients shall be determined by the following :

a = STBY / INPUT

b = INPUT

$$a = \frac{STBY}{INPUT}$$

$$b = \frac{(INPUT \times RE^{*}) - STBY}{SRL}$$

* or Thermal Efficiency (TE)

PLRn = Part-load ratio for the nth hour and shall always be less than 1. PLR n is calculated from the following equation:

$$PLR_n = \frac{SRL \times F_{whpl(n)}}{INPUT \times RE^{*}}$$

* or Thermal Efficiency (TE)

INPUT = The input capacity of the water heater expressed in Btu/hr.

STBY = Hourly standby loss expressed in Btu/hr. For large storage gas water heaters STBY is listed in the CEC's appliance database. The value includes pilot energy and standby losses. For all other systems refer to equation N2-62.

SRL = the Standard Recovery Load, taken from Appendix 5.4A, in Btu/hr, adjusted for the number of occupants according to the occupancy schedules.

For Boilers, Instantaneous gas or other storage type water heaters, not in the scope of Covered Consumer Products as defined in the Title 10 or the Code of Federal Regulations, Part 430;

$$STBY = 453.75 \times S \times VOL$$

Where:

S = The standby loss fraction listed in the Commission's Appliance Database of Certified Water Heaters,

VOL = The actual storage capacity of the water heater as listed in the Commission's Appliance Database of Certified Water Heaters,

Required inputs and standard and proposed design assumptions depend on the type of water heater and whether or not it is a DOE covered consumer product.

Standard Design	Not applicable

5.9.1.3 Recirculation Systems

This section describes the building descriptors for hot water recirculation systems. The baseline building has a recirculation system when the proposed design does. This is one aspect of the *water heating system configuration* (see above).

Recirculating systems shall follow the rules set forth in Appendix E of the 2013 Residential ACM Manual.

5.9.1.4 Water Heating Auxiliaries

External Storage Tank Insulation	
Applicability	All water heating systems that have an external storage tank
Definition	Some water heating systems have a storage tank that is separate from the water heater(s) that provides additional storage capacity. This building descriptor addresses the heat loss related to the external tank, which is an additional load that must be satisfied by the water heater(s).
Units	R-value (h-ft2-F/Btu)
Input Restrictions	As specified in manufacturer data and documented on the construction documents
Standard Design	Heat loss associated with the storage tank in the baseline building shall meet the requirements for an unfired storage tank in the baseline standards which is an insulation R-value of 12.5. The surface area and location of the storage tank shall be the same as the proposed design.

External Storage Tank Area	
Applicability	All water heating systems that have an external storage tank
Definition	Some water heating systems have a storage tank that is separate from the water heater(s) that provides additional storage capacity. This documents the entire exterior surface area of the tank.
Units	ft2
Input Restrictions	As specified in manufacturer specifications
Standard Design	Not applicable

External Storage Tank Location	
Applicability	All water heating systems that have an external storage tank
Definition	Location of the storage tank, used to determine the heat loss rate and energy exchange with the surroundings
Units	List: Schedule, Zone, Outdoors
Input Restrictions	As designed
Standard Design	Not applicable

Heat Recovery

Applicability	Water heating systems that are coupled to heat recovery equipment
Definition	Building equipment such as air conditioners, chillers, gas fired generators, etc. produce thermal energy that may be recovered and used to heat water. The heat producing characteristics are generally defined for the equipment that is producing the heat, not the equipment that is receiving the heat (water heaters in this case). The building descriptors will vary depending on the equipment. The models for heat producing equipment need to produce output on an hourly basis so that the schedule of heat production and heating needs can be aligned and evaluated in the water heating model.
Units	Data structure: depends on the equipment producing the heat
Input Restrictions	There are no restrictions, other than agreement with the construction documents.
Standard Design	Not applicable

Solar Thermal

Applicability	Water heating systems with a solar thermal system
Definition	A solar thermal water heating system consists of one or more collectors. Water is passed through these collectors and is heated under the right conditions. There are two general types of solar water heaters: integrated collector storage (ICS) systems and active systems. Active systems include pumps to circulate the water, storage tanks, piping, and controls. ICS systems generally have no pumps and piping is minimal. Solar systems may be tested and rated as a complete system or the collectors may be separately tested and rated. SRCC OG-300 is the test procedure for whole systems and SRCC OG-100 is the test procedure for collectors. The building descriptors used to define the solar thermal system may vary with each software application and with the details of system design. The solar fraction shall be estimated by the f-chart procedure for solar water heating systems.
Units	Unitless fraction
Input Restrictions	The solar fraction provided by the solar DHW system shall be between 0 and 1.
Standard Design	The baseline building has no solar auxiliary system.

Combined Space Heating and Water Heating

Applicability	Projects that use a boiler to provide both space heat and water heating
Definition	A system that provides both space heating and water heating from the same equipment, generally the space heating boiler. Such systems are restricted by the baseline standards, but may be modeled in the candidate building. The restrictions are due to the misalignment of the space heating load and the water heating load. The first is highly intermittent and weather dependent, while the latter is more constant and not generally related to the weather.
Units	Data structure
Input Restrictions	The proposed design may have a combined space and water heating system.
Standard Design	The baseline building shall be modeled with separate space heating and water heating systems

5.9.2 Exterior Lighting

Outdoor lighting requirements are specified in Standards section 140.7. Outdoor lighting shall not be modeled in the proposed design or standard design, and no tradeoffs are available with other building end uses or systems. Outdoor lighting shall meet all prescriptive requirements in the Standards. Compliance software shall accept user input for outdoor lighting and verify that the proposed design outdoor lighting does not exceed the standard design outdoor lighting, and shall include verification of compliance on the appropriate compliance form(s).

5.9.3 Swimming Pools

Swimming pools must meet applicable mandatory requirements and are not required to be modeled for California Title 24 compliance or Reach.

5.9.4 Other Electricity Use

This set of building descriptors should be used to include any miscellaneous electricity use that would add to the electric load of the building and would be on the building meter. These energy uses are assumed to be outside the building envelope and do not contribute heat gain to any thermal zone.

Miscellaneous Electric Power	
Applicability	All buildings with miscellaneous electric equipment located on the building site
Definition	The power for miscellaneous equipment.
Units	Watts (W)
Input Restrictions	As designed.
Standard Design	Same as the proposed design

Miscellaneous Electric Schedule	
Applicability	All buildings with miscellaneous electric equipment located on the building site
Definition	The schedule of operation for miscellaneous electric equipment. This is used to convert electric power to energy use.
Units	Data structure: schedule, fractional
Input Restrictions	The schedule specified for the building should match the operation patterns of the system.
Standard Design	Same as the proposed design

5.9.5 Other Gas Use

This set of building descriptors should be used to include any miscellaneous gas use that would add to the load of the building and would be on the building meter. These energy uses are assumed to be outside the building envelope and do not contribute heat gain to any thermal zone.

Other Gas Power	
Applicability	All buildings that have commercial gas equipment
Definition	Gas power is the peak power which is modified by the schedule (see below).

Units	Btu/h-ft²
Input Restrictions	As designed
Standard Design	Same as the proposed design

Other Gas Schedule	
Applicability	All buildings that have commercial gas equipment
Definition	The schedule of operation for commercial gas equipment. This is used to convert gas power to energy use.
Units	Data structure: schedule, fractional
Input Restrictions	Continuous operation is prescribed.
Standard Design	Same as the proposed design

5.10 On-Site Power Generation

Building projects may incorporate other on-site electricity generation equipment, such as cogeneration plants or fuel cells that make electricity and produce heat. Projects may also include wind turbines. These systems may be modeled in various ways and the building descriptors described below should be considered an example of one set. In all cases, the baseline building will be modeled without on-site generation equipment. If there is no thermal link between the power generation equipment and building equipment (such as heat recovery from CHP), on-site power generation can be modeled in a separate process; otherwise, it needs to be linked to the building simulation.

RESERVED FOR FUTURE USE – onsite power generation systems are not currently modeled for Title 24 compliance or reach. Qualifying solar water heating systems are specified by a solar fraction, and referenced in Section 5.9.

5.11 Common Data Structures

This section describes common data structures referenced in this chapter. The data structures presented here define objects and example parameters needed to define them. The parameters described are the most common for energy simulation engines. However, other parameters or data constructs are acceptable; however, the fields used by the simulation program must be mapped to the fields used by the building descriptor..

5.11.1 Schedule

This data structure provides information on how equipment, people, lights, or other items are operated on an hourly basis. The ultimate construct of a schedule is an hourly time series for the simulation period, typically 8,760 hours (365 days, 24 hours/day). However, software has often built up the hourly schedule from 24-hour schedules for different day types: weekdays, Saturdays, Sundays, holidays, etc.

There are several types of schedules:

- **Temperature** schedules specify a temperature to be maintained in a space, a temperature to be delivered from an air handler, or the leaving temperature from a chiller or other equipment.
- **Fraction** schedules specify the fraction of lights that are on, the fraction of people that are in the space, the fraction of maximum infiltration, or other factors.

- **On/off** schedules specify when equipment is operating or when infiltration is occurring.
- **Time period** schedules define periods of time for equipment sequencing, utility tariffs, etc. A time period schedule typically breaks the year in to two or more seasons. For each season, day types are identified such as weekday, Saturday, Sunday and holidays. Each day type in each season is then divided into time periods.

5.11.2 Holidays

A series of dates defining holidays for the simulation period. Dates identified are operated for the schedule specified for holidays.

5.11.3 Surface Geometry

This data structure represents the location, size, and position of a surface. Surfaces include roofs, walls, floors, and partitions. Surfaces are typically planar and can be represented in various manners, including the following:

- Rectangular surfaces may be represented by a height and width along with the X, Y, and Z of surface origin and the tilt and azimuth
- Surfaces may also be represented by a series of vertices (X, Y, and Z coordinates defining the perimeter of a surface). More complex polygons may be represented in this manner.

5.11.4 Opening Geometry

This data structure represents the location and size of an opening within a surface. The most common method of specifying the geometry of an opening is to identify the parent surface, the height and width of the opening, and the horizontal and vertical offset (X and Y coordinates relative to the origin of the parent surface). An opening can also include a recess into the parent surface, which provides shading. However, other geometric constructs are acceptable.

5.11.5 Opening Shade

This data structure describes the dimensions and position of external shading devices such as overhangs, side fins, or louvers that shade the opening. Overhangs are specified in terms of the projection distance, height above the opening, and extension distance on each side of the opening.

5.11.6 Construction Assembly

This data structure describes the layers that make up the construction of a wall, roof, floor, or partition. Typically, a construction consists of a sequence of materials, described from the outside surface to the inside surface.

5.11.7 Fenestration Construction

This data structure describes the frame, glass, and other features of a window or skylight. Information may be defined in multiple ways, but the criteria themselves are published as a combination of U-factor, solar heat gain coefficient (SHGC), and visible light transmission (VT). Some simulation programs use more detailed methods of describing the performance of fenestration that take into account the angle of incidence of sun striking the fenestration and other factors, such as the properties of each pane and the fill. The compliance software only uses whole window performance properties (U-factor, SHGC, VT).

5.11.8 Material

This data structure describes a material that is used to build up a construction assembly. Typical material properties include specific heat, density, conductivity, and thickness. Materials can also be described in terms of their thermal resistance. The latter approach is sometimes used to approximate construction layers that are not homogeneous, such as framing members in combination with cavity insulation.

5.11.9 Slab Construction

This data structure describes the composition of a slab-on-grade. The compliance model has building descriptors for the perimeter length and the F-factor, which represents the heat loss per lineal foot.

5.11.10 Exterior Surface Properties

This data structure describes the characteristics of exterior surfaces. Exterior surface properties may include emissivity, reflectivity, and roughness. The first two govern radiation exchange from the surface, while the latter governs the magnitude of the exterior air film resistance.

5.11.11 Occupant Heat Rate

This data structure represents the rate of heat and moisture generated by building occupants. This is typically specified in terms of a sensible heat rate and a latent heat rate. Both are specified in Btu/h.

5.11.12 Furniture and Contents

This data structure represents the thermal mass effect of furniture and other building contents. This is expressed in terms of lb/ft^2 for the space in question.

5.11.13 Reference Position in a Space

This data structure locates a reference point in a space, typically for the purposes of daylighting control. The typical construct for the reference point is a set of coordinates (X, Y, and Z) relative to the space coordinate system.

5.11.14 Two Dimensional Curve

This data structure explains one parameter in terms of another. An example is a curve that modifies the efficiency of an air conditioner relative to the fraction of time that the equipment operates within the period of an hour, for example. The relationship can be expressed in terms of the X and Y coordinates of points on the curve or it can be expressed as an equation.

5.11.15 Three Dimensional Curve

This data structure explains one parameter in terms of two others. An example is a curve that modifies the efficiency of an air conditioner relative to the outside air dry-bulb temperature and the wet-bulb temperature of air returning to the coil. The relationship is a three-dimensional surface and can be expressed in terms of the X and Y coordinates of points on the curve or it can be expressed as an equation.

5.11.16 Temperature Reset Schedule

This data structure describes the relationship between one temperature and another. For example, the independent variable might be outside air temperature and the dependent variable is supply air temperature. In this case, a common schedule would be to set the supply air temperature at 55°F when the outside air temperature is 80°F or warmer and at 62°F when the outside air temperature is 58°F or cooler with the supply air temperature scaling between 55°F and 62°F when the outside air temperature is between 80°F and 58°F.